EELLS

An Investigation of the Stresses in Cantilever Flat Slabs

Theoretical and Applied Mechanics

M. S.

1913

AN INVESTIGATION OF
THE STRESSES IN CANTILEVER FLAT SLABS

BY

WILLARD CLARK EELLS

B. S. University of Illinois, 1911

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF SCIENCE

IN THEORETICAL AND APPLIED MECHANICS

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1913

1913
E25

T. & A.M.

UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

June 2, 1913. 190

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

WILLARD CLARK EELLS

ENTITLED An Investigation of the Stresses in Cantilever Flat Slabs

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of Science in Theoretical and Applied Mechanics.

A. N. Talbot
In Charge of Major Work

A. N. Talbot
Head of Department

Recommendation concurred in:

Committee
on
Final Examination

AN INVESTIGATION OF

THE STRESSES IN CANTILEVER FLAT SLABS

TABLE OF CONTENTS

I. INTRODUCTION

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

AN INVESTIGATION OF
THE STRESSES IN CANTILEVER FLAT SLABS

I. INTRODUCTION.

1. Preliminary.- In the design of the flat slab type of floors for reinforced concrete buildings there is, at the present time, a wide variation among different designers in methods of calculation and results obtained. In the Middle West there are at least four firms who have been apparently successful in handling this type of construction. No two of these firms use the same or even similar methods of calculation for the amount and position of the steel, the thickness of the slabs, or the concrete stresses, although the results obtained by three of the four companies in mind probably do not differ widely. As a basis for their design the Corrugated Bar Company uses the results of tests made on a uniformly loaded rubber plate supported by columns, as described in a pamphlet issued by this company. The other companies use more or less empirical formulas for their results. Thus far no one seems to have solved satisfactorily the problem of slab action in a non-homogeneous material such as reinforced concrete.

Two points of view seem to exist with reference to the proper method of attacking the problem under consideration. In the first of these the loaded area is divided into strips of more or less irregular shape and a beam action considered.

This method probably gives results on the side of safety for the conditions imposed are more severe than those which are shown to exist by actual tests of buildings. The second method of attack is to consider both a radial and circumferential resisting moment as existing in the floor around the column capital, with a certain relation between them. Based on an analysis for homogeneous flat plates by Dr. Eddy of the University of Minnesota, Turneaure and Maurer give diagrams for the calculation of both radial and circumferential bending moments in their text on Principles of Reinforced Concrete Construction. In Engineering News of April 18, 1912, Prof. S. E. Slocum of the University of Cincinnati presents an article entitled, "A Method of Analyzing Radially Reinforced Flat Slabs" in which he compares the theoretical effectiveness of tensile reinforcement in the form of hoops with the same cross-sectional area of direct or radial reinforcement. He also makes the comparison on the basis of equal volumes of steel placed in the two directions. A criticism of Prof. Slocum's article by C. A. P. Turner, a designing engineer in Minneapolis, Minnesota, may be found in Engineering News of May 16, 1912. None of the sources of information mentioned handles the problem in a manner not open to serious objection.

The series of tests described in this thesis was planned to throw light on the distribution of the radial and circumferential stresses around a column capital in flat slab construction and the relation between the two, by means of a measurement of the deformations. It is hoped that the results will be helpful in furnishing a method of attack for solving the problem of what actually happens in a flat slab under load.

2. Scope of Investigation.- The investigation was planned with the view of securing information on the following principal points: (1) action in slabs containing circumferential rods or hoops alone as reinforcement; (2) action in slabs containing radial rods alone; (3) action in slabs containing a combination of hoops and radial rods; and, (4) action in slabs containing two layers of rods placed at right angles.

The tests were planned to obtain the most information on these points with the limited number of specimens which could be properly tested and the results put into shape in the time allotted. The results may not be directly applicable for use in commercial design, as the tests were made more for the purpose of forming a basis for analysis.

3. Acknowledgment.- These tests were made as a part of the research work of the University of Illinois Engineering Experiment Station. They were undertaken under the supervision of Prof. A. N. Talbot, to whom credit is due for the design of the specimens and for many helpful criticisms and interpretations of the results. Direct supervision of the work of making the test specimens and many valuable suggestions for conducting the tests were given by Mr. D. A. Abrams, Associate in the Engineering Experiment Station. Mr. H. R. Thomas and Mr. G. A. Maney, Research Fellows in the Engineering Experiment Station, assisted in making the tests and Mr. Maney helped in the work on theory. To these and other members of the staff acknowledgment is made for assistance and experienced counsel.

II. MATERIALS, TEST PIECES, AND METHODS OF TESTING

II. MATERIALS, TEST PIECES, AND METHODS OF TESTING.

4. Properties of Materials.- The cement used was furnished by the Universal Portland Cement Company. Tests of samples taken at times through the season and made by B. L. Bowling, assistant in charge of the Cement Laboratory, are given in Table 1.

Table 1.

TENSILE STRENGTH OF CEMENT.

Each value is the average from five tests.

Sample No.	Date	Age 7 days		Age 28 days	
		Neat	1:3 Standard Sand	Neat	1:3 Standard Sand
1	Dec. 14, 1912	584	201	765	302
2	Jan. 10, 1913	592	211	712	285
3	Feb. 12, 1913	608	210	743	315

Additional tests on the cement showed the initial set to occur in 3 hr. - 0 min. and final set to occur in 6 hr. - 25 min.

The sand used was torpedo sand from Attica, Indiana. It was from the same shipment as that used in concrete specimens tested during the year 1912, and was from the same locality and of the same quality as that used in making reinforced concrete test specimens for several years. It was of good quality, fairly sharp, clean and well graded. The average results of mechanical analyses made on five samples taken at times during the season are given in Table 2.

Table 2.

MECHANICAL ANALYSIS OF SAND.

Sieve No.	Separation Size, in.	Per cent Passing
3	0.28	100
5	.174	90.9
10	.091	69.1
12	.067	63.8
16	---	58.3
18	.043	48.4
30	.027	31.1
40	.019	19.5
50	.013	6.5
74	.009	2.9
150	---	.9

A good quality of rather hard Kankakee limestone specified to pass through a 1-in. screen and over a $\frac{1}{4}$-in screen, was used. It was taken from the same shipment as that used in the 1912 concrete test specimens and was of the same quality as that used in previous years. The results of a mechanical analysis of samples from the same shipment may be found in the thesis of H. F. Millard, written in 1912.

The steel reinforcement consisted of plain round rods of medium hardness. The results of tensile tests made on specimens of the steel are given in Table 3.

Table 3.

TENSILE TESTS OF STEEL.

Size	No. Samples Tested	Yield Point		Ultimate	
		lb. per sq.in.	Maximum Per cent Variation from Mean	lb. per sq.in.	Maximum Per cent Variation from Mean
1/2-in.	10	39 400	5.3	59 500	6.0
7/16-in.	10	38 300	3.8	54 500	3.5
3/8-in.	10	42 000	2.7	58 200	2.3

5. Concrete.- The concrete used was a 1-2-4 mixture. The sand and stone were measured in buckets by loose volume and a bag of cement (95 lb.) considered as 1 cubic foot of volume. The resulting proportions by weight are given in Table 4.

Table 4.

PROPORTIONS OF CONCRETE INGREDIENTS BY WEIGHT.

Slab No.	Cement	Sand	Stone
1241	1	2.07	3.38
1242	1	2.34	3.78
1243	1	2.25	3.68
1244	1	2.23	3.77
1245	1	2.31	3.74
1246	1	2.27	3.61
1247	1	2.40	3.87

2,29 3.69

Men skilled in mixing and placing concrete were used in the work, the foreman being an experienced concrete workman who has made the specimens for the laboratory for eight seasons. The mixing was done in a Marsh-Capron batch mixer with a rated capacity of 9 cubic feet. The stone was first dumped in, about two-thirds of the water added, the sand and cement put in in the order named, and finally the remainder of the water allowed to enter. Enough water was used to produce a wet mixture that would run freely from the shovel. The mixer was allowed to run for a period of five minutes on each batch. Four or five batches were required for each specimen, and the entire amount was usually mixed and dumped on the concrete floor of the laboratory before any of it was carried to the forms.

6. Design of Test Specimens.- It was thought best for the purpose of this investigation to make all the slabs circular in

One [illegible] of slabs [illegible]

View of Concrete Laboratory

Showing Slabs in Storage.

for W. S. Eells
Return to J.O.A.Ser. Dept.

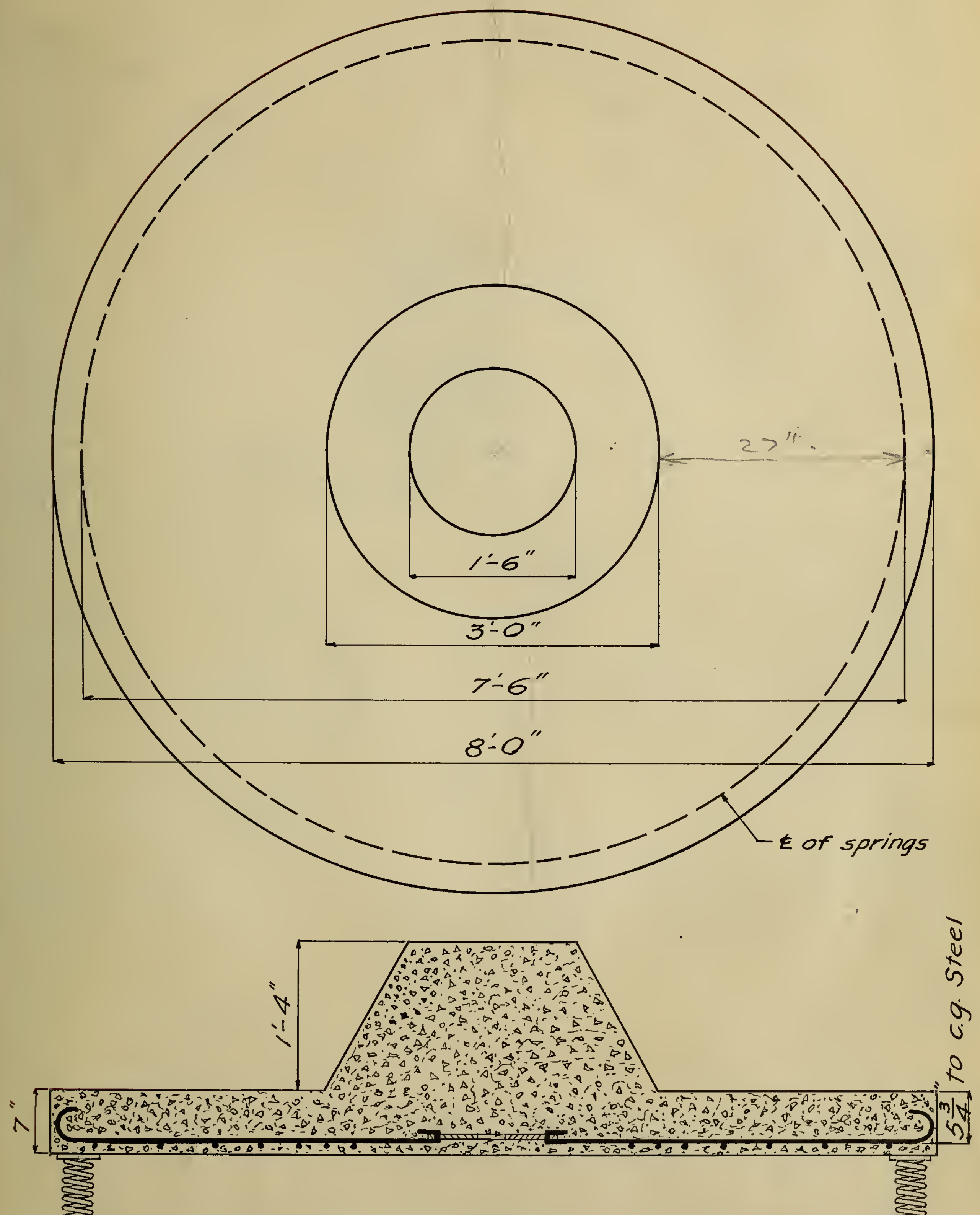
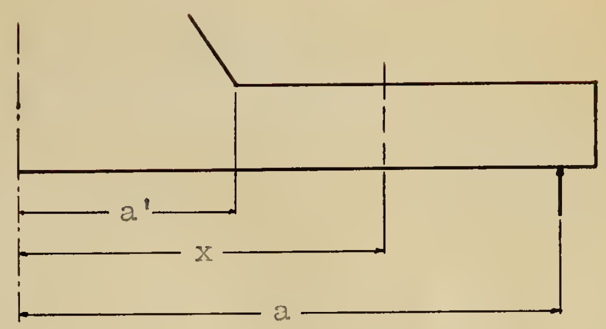


Fig. 1. Dimensions of All Specimens.

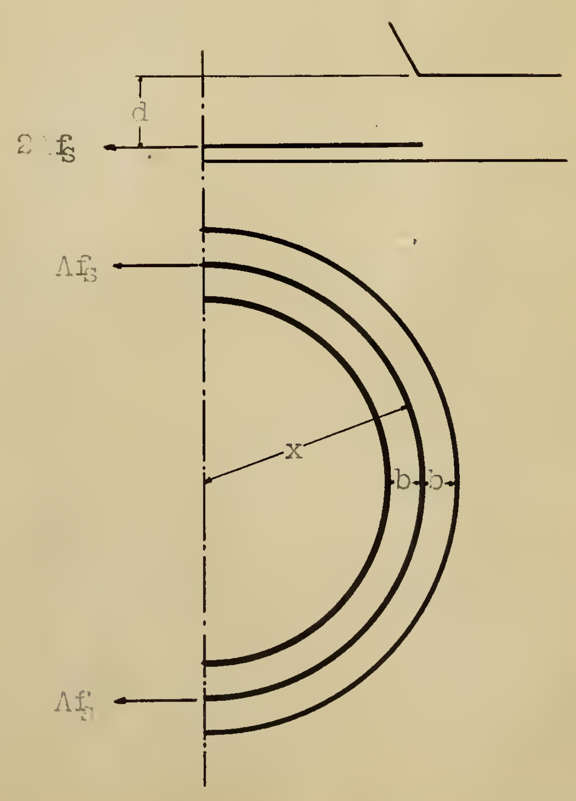
form. Deformation readings could then be taken radially and circumferentially at varying distances from the centers of the slabs. In square-shaped specimens complications might arise to prevent truly circumferential deformations being obtained. After consideration which was partly theoretical and partly the result of past experience in making test specimens of this sort, all slabs were designed to have the dimensions shown in Fig. 1. These dimensions were such as to fit the testing-machine which had been built two years previous. Seven slabs were decided upon; two to be reinforced with circumferential steel only; two to be reinforced with radial steel only; two to be reinforced with both radial and circumferential steel; and one to contain two layers of steel placed at right angles, which last form will be designated as rectangular reinforcement. The circumferential steel rods or hoops were to be welded, the radial steel rods were to be hooked into a steel plate at the center and 180-degree bends made at their outer ends to prevent slipping in the concrete, and the rectangular reinforcement was to be hooked at the ends also to prevent slipping. Two specimens with each form of reinforcement except the rectangular were required to furnish a check on the results, the rectangular form being used more to furnish data for comparison with the others. It was decided that with this number of specimens sufficient data could be obtained for a study of the effect of different forms of reinforcement upon the radial and circumferential deformations. A study of the effectiveness of circumferentially placed reinforcing rods in comparison with the other forms could also be made.

In the approximate work of designing for the amount and

position of the reinforcing steel a radial bending moment was considered. In the figure shown, the bending moment at a circular section out a distance x from the center is equal to W(a-x), where W is the total load on the slab. For radial reinforcement alone the resisting moment is equal to Af_sjd, where the notation is the one in general use and found in Turneaure and Maurer's Principles of Reinforced Concrete Construction. Equating resisting and bending moments $W(a-x) = Af_sjd$ or $W = \frac{Af_sjd}{a-x}$. The worst condition is to be found at the edge of the column capital. Let jd = 5 in. and f_s = 40 000 lb. per sq. in. At the edge of the column capital a-x = 27 in. For 60 - ½-in. round rods W = 87 000 lb., for 48 - ½-in. round rods W = 70 000 lb., and for 36 - ½-in. round rods W = 52 000 lb.



For the circumferential rods the resisting moment may be calculated from the figure shown, to be $\frac{2\pi xAjdf_s}{b}$. Equating resisting and bending moments and solving for W, $W = \frac{2\pi xAjdf_s}{(a-x)b}$. At the edge of the column capital x = 18 in. and a-x = 27 in. Let jd = 5 in., f_s = 40 000 lb. per sq. in., and use ½-in. round rods. Then for



b = 4 in. W = 41 000 lb., for b = 3 in. W = 55 000 lb., and for b = 2 in. W = 82 000 lb. At a distance x = 27 in. for b = 7 in. W = 51 000 lb., for b = 6 in. W = 60 000 lb., and for b = 5 in. W = 72 000 lb. From this method of analysis it would follow that the spacing of the hoops should increase as the distance from the center becomes greater.

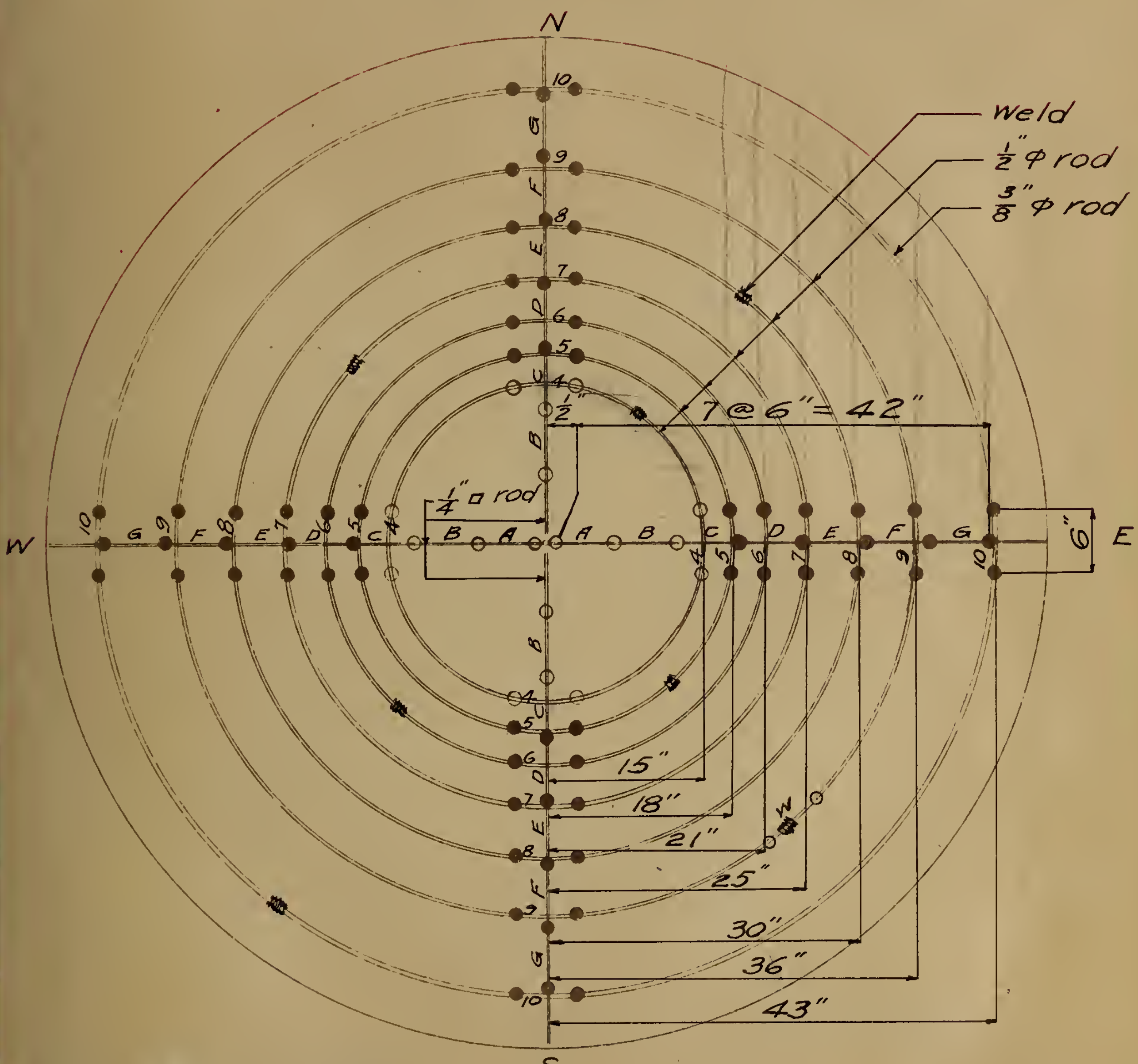
It was decided to reinforce the slabs containing radial reinforcement only and those containing circumferential reinforcement only with sufficient steel to withstand a load of about 50 000 lb. according to the calculations made, and to put this amount of radial and circumferential steel in each of the slabs containing both forms. The slab containing the rectangular form of reinforcement was designed to contain about the same volume of steel as those containing both radial and circumferential rods. Figs. 2, 3, 4, 5, 6, 7 and 8 give the amount and position of the reinforcement for all the specimens as finally designed. Table 5 gives a summary of the amounts of steel used in the specimens.

Table 5.

DATA OF TEST SLABS.

Slab No.	Circumferential Rods	*Radial Rods	Thickness of Plate	Percentage "A"	Percentage "B"
1241	6 - 1/2-in.rd.	none	-------	.573	.621
1242	1 - 3/8-in.rd.	none	-------	.573	.621
1243	none	36	1/2-in.	.870	.621
1244	none	36	3/8-in.	.870	.621
1245	6 - 1/2-in.rd.	36	3/8-in.	1.443	1.242
1246	1 - 3/8-in.rd.	36	1/2-in.	1.443	1.242
	Reinforcement				
1247	42 - 7/16-in.rd. rods placed in two layers at right angles.			1.289	1.244

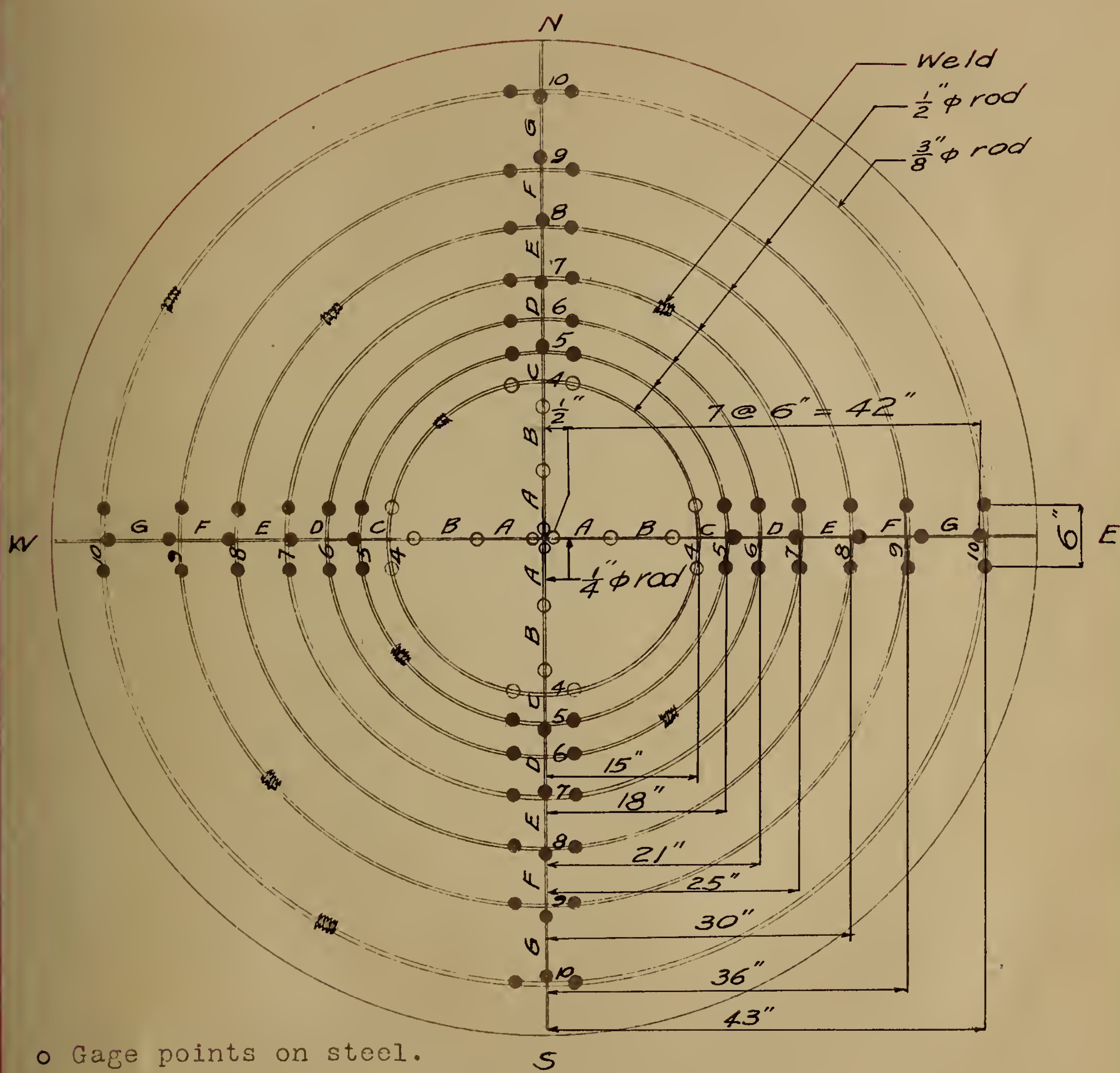
*,- All 1/2-in. rd. rods.



o Gage points on steel.

● Gage points on steel below and concrete above.

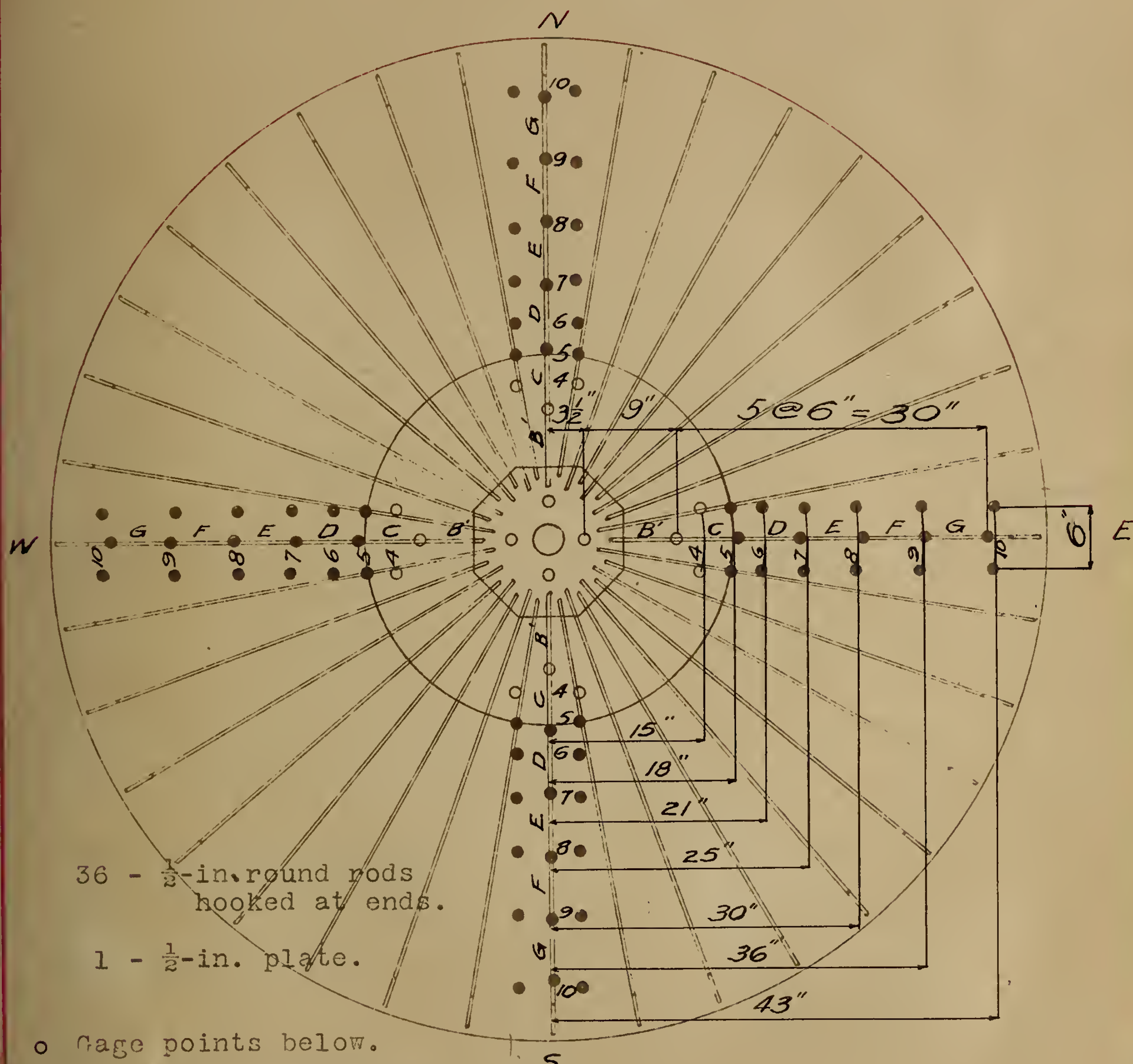
Fig. 2. Slab 1241.-Location of Steel and Gage Lines.



o Gage points on steel.

● Gage points on steel below and concrete above.

Fig.3. Slab 1242.-Location of Steel and Gage Lines.



○ Gage points below.

● Gage points below and on concrete above.

Fig.4. Slab 1243.-Location of Steel and Gage Lines.

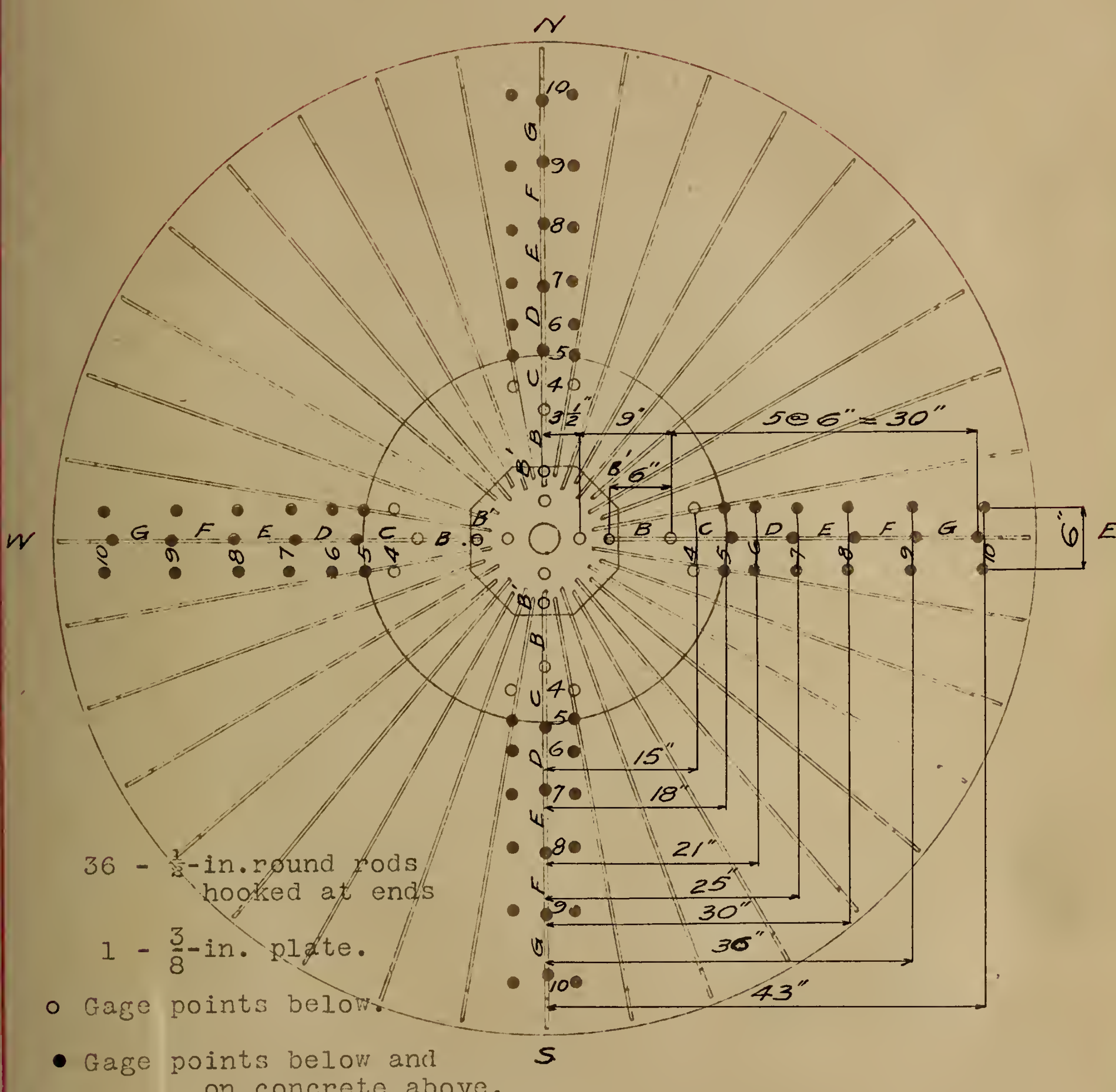
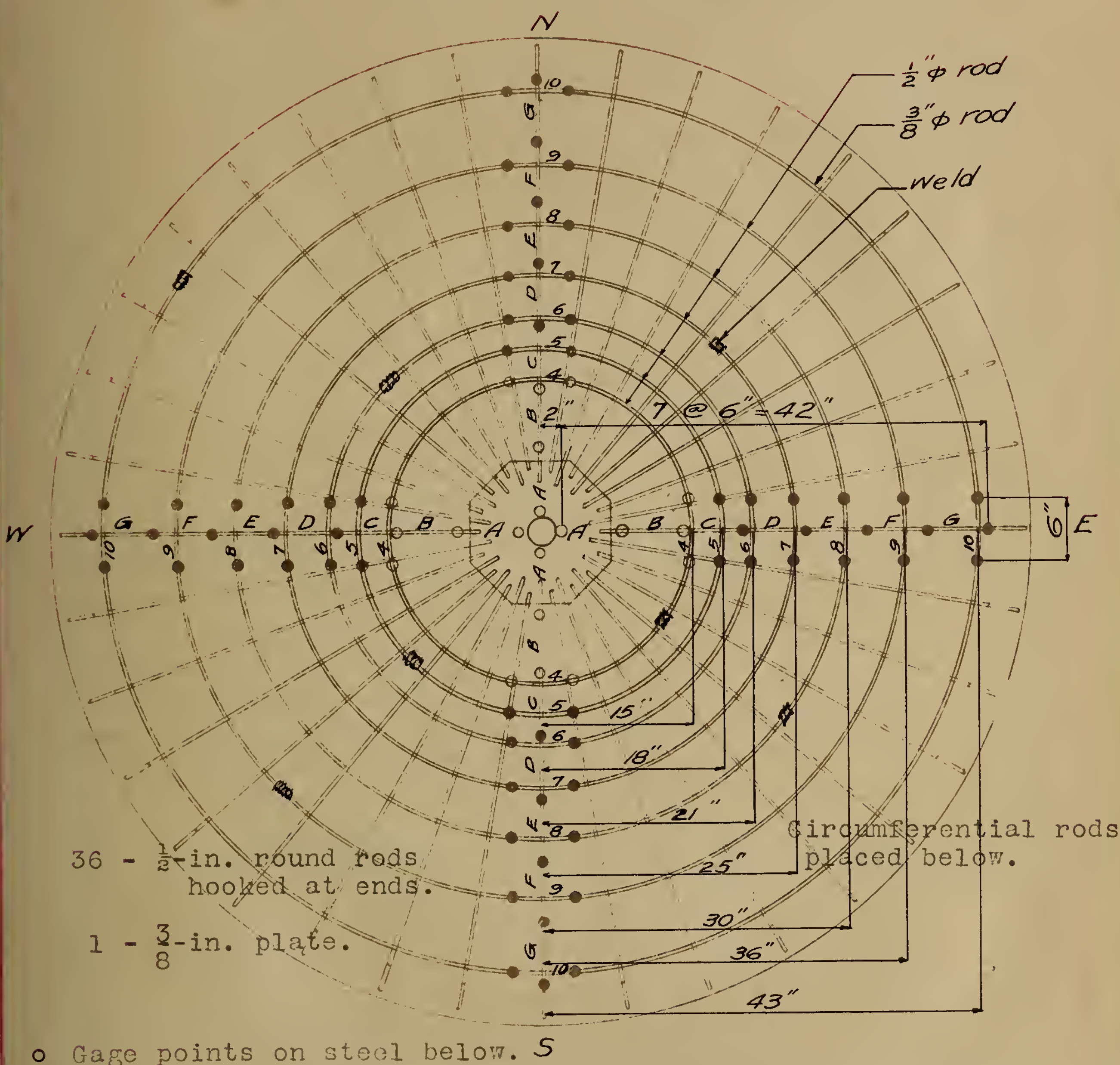


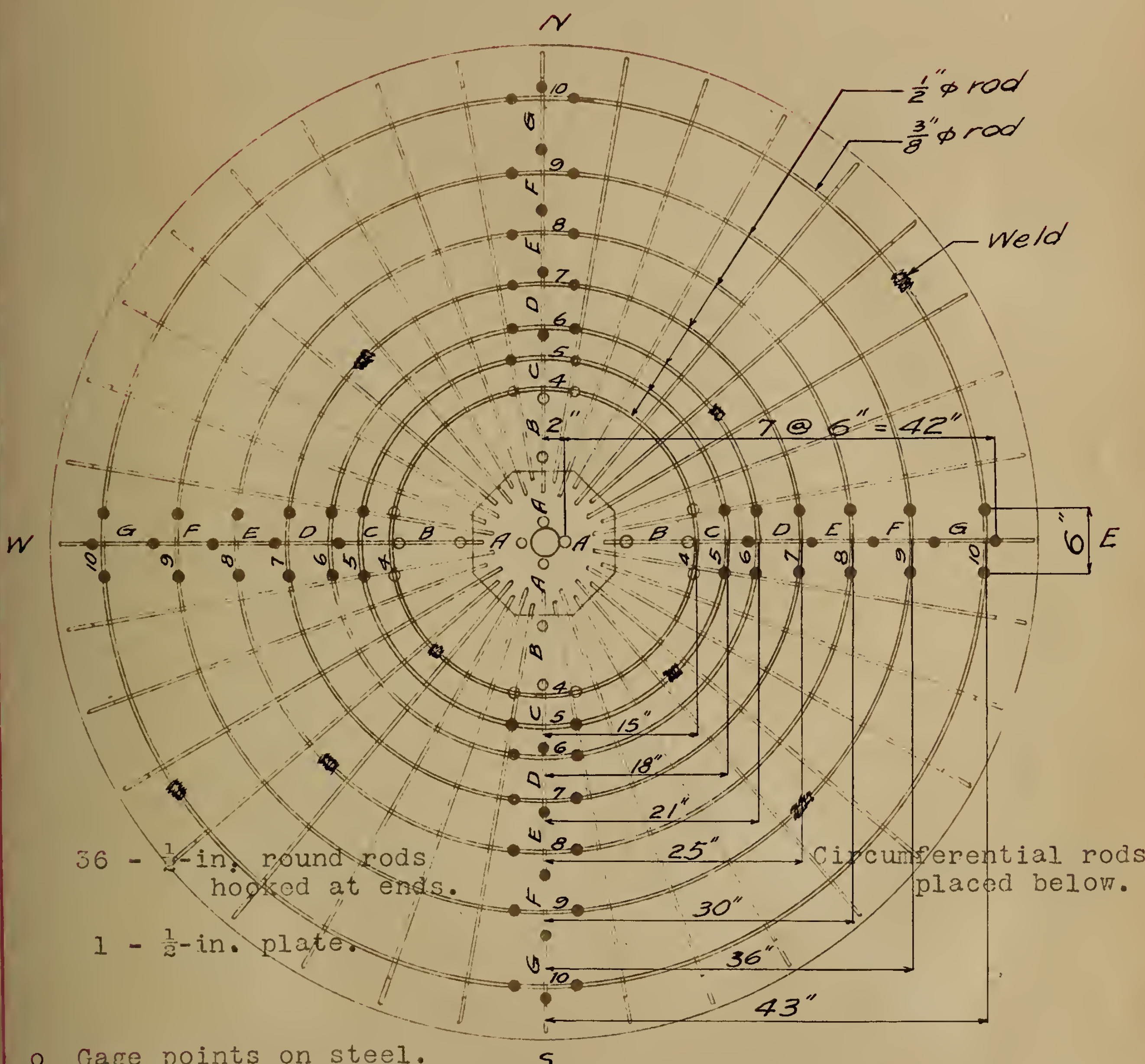
Fig.5. Slab 1244.-Location of Steel and Gage Lines.



o Gage points on steel below.

● Gage points on steel below and concrete above.

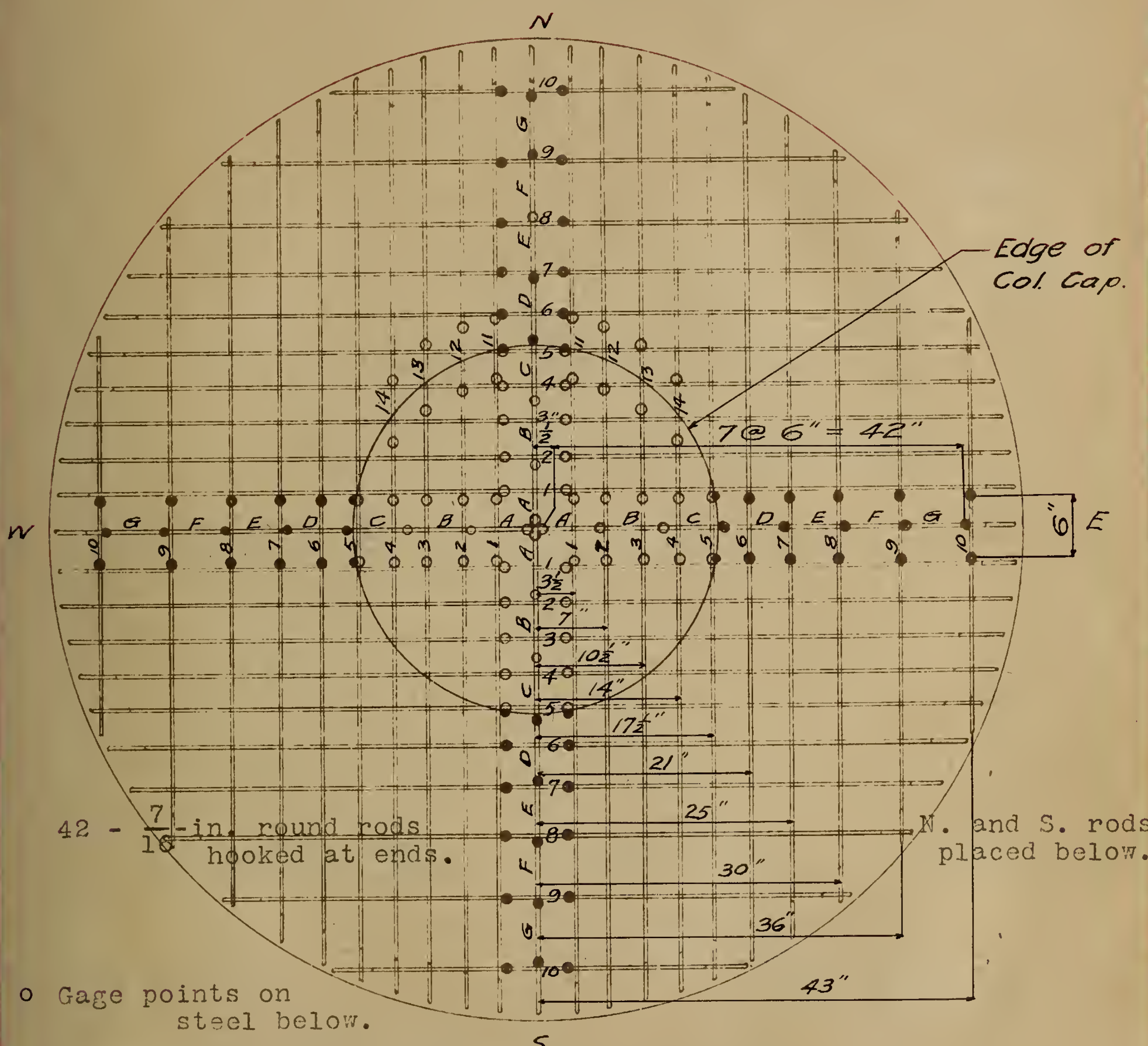
Fig. 6. Slab 1245.-Location of Steel and Gage Lines.



o Gage points on steel.

● Gage points on steel below and concrete above.

Fig. 7. Slab 1246.-Location of Steel and Gage Lines.



42 - $\frac{7}{16}$-in. round rods hooked at ends.

N. and S. rods placed below.

o Gage points on steel below.

• Gage points on steel below and concrete above.

Fig. 8. Slab 1247.-Location of Steel and Gage Lines..

In calculating percentages the only logical method would seem to be to divide the volume of steel by the total volume of the slab down to the center of gravity of the steel. Percentage "A" in Table 5 was calculated by considering the volume of steel inside the circular line of support, each radial rod being considered to extend through the center of the slab. Percentage "B" was calculated by considering the volume of steel between the edge of the column capital and the line of support and the volume of the slab between the same limits. In many respects the method of calculating percentage "B" would seem the more logical of the two, especially for purposes of comparison.

In the description of these tests, terms will be used for which somewhat arbitrary definitions will need to be made. These definitions are given here:

Gage Hole or Gage Point: A small hole (.055 in. in this investigation) drilled into the steel rod or into the steel plug inserted in the concrete.

Gage Line: The gaged length connecting a pair of gage holes.

Reading: A reading is a single observation on any gage line.

Observation: An observation as here used is the average of a number of readings.

These definitions are taken from bulletin No. 64 of the University of Illinois Engineering Experiment Station.

It was decided to take deformation readings both radially and circumferentially at four sections around the column capital at 90 degrees from each other. Outside the edge of the column capital a gage line on the concrete was to be located directly above each gage line on the tension side of each specimen.

Figs. 2, 3, 4, 5, 6, 7, and 8 show the location of these gage lines. The scheme for numbering the gage lines is quite simple. All gage lines to the north of the centers of the slabs as they were placed on the testing-machine are designated by N, those to the east by E, those to the south by S, and those to the west by W. The gage lines for taking circumferential deformations are designated by numbers as 4, 5, 6, and those for taking radial deformations by letters as A, B. No special marking is used to differentiate between gage lines on the compression and tension sides of the slabs, but these are in all cases given under separate headings.

7. Method of Making Test Specimens.- The forms for the slabs consisted of four planks of the proper width and a strip of sheet-iron bent into the form of an 8-ft. circle and reinforced by two strips of strap-iron. The planks were laid edgewise in the form of a square and the sheet-iron placed inside and braced into position. A good view of the forms may be seen in Figs. 9 and 11. Heavy building paper was placed on the concrete floor of the laboratory under the forms, no wooden bottom being used.

The circumferential reinforcing rods were bent into the form of circles and the ends welded together. The welding for slabs 1241 and 1245 was done in a blacksmith's forge and that in slabs 1242 and 1246 was done with an oxy-acetylene blow-torch. Figs. 9 and 11 show the appearance of the circumferential rods in place. The welds were staggered as shown in Figs. 2, 3, 6, and 7. The $\frac{1}{4}$-in. rods for taking radial deformations were not hooked at the ends.

The radial reinforcement consisted of 36 - $\frac{1}{2}$-in. round rods

Fig.9. Slab 1241.-View of Forms and Reinforcement.

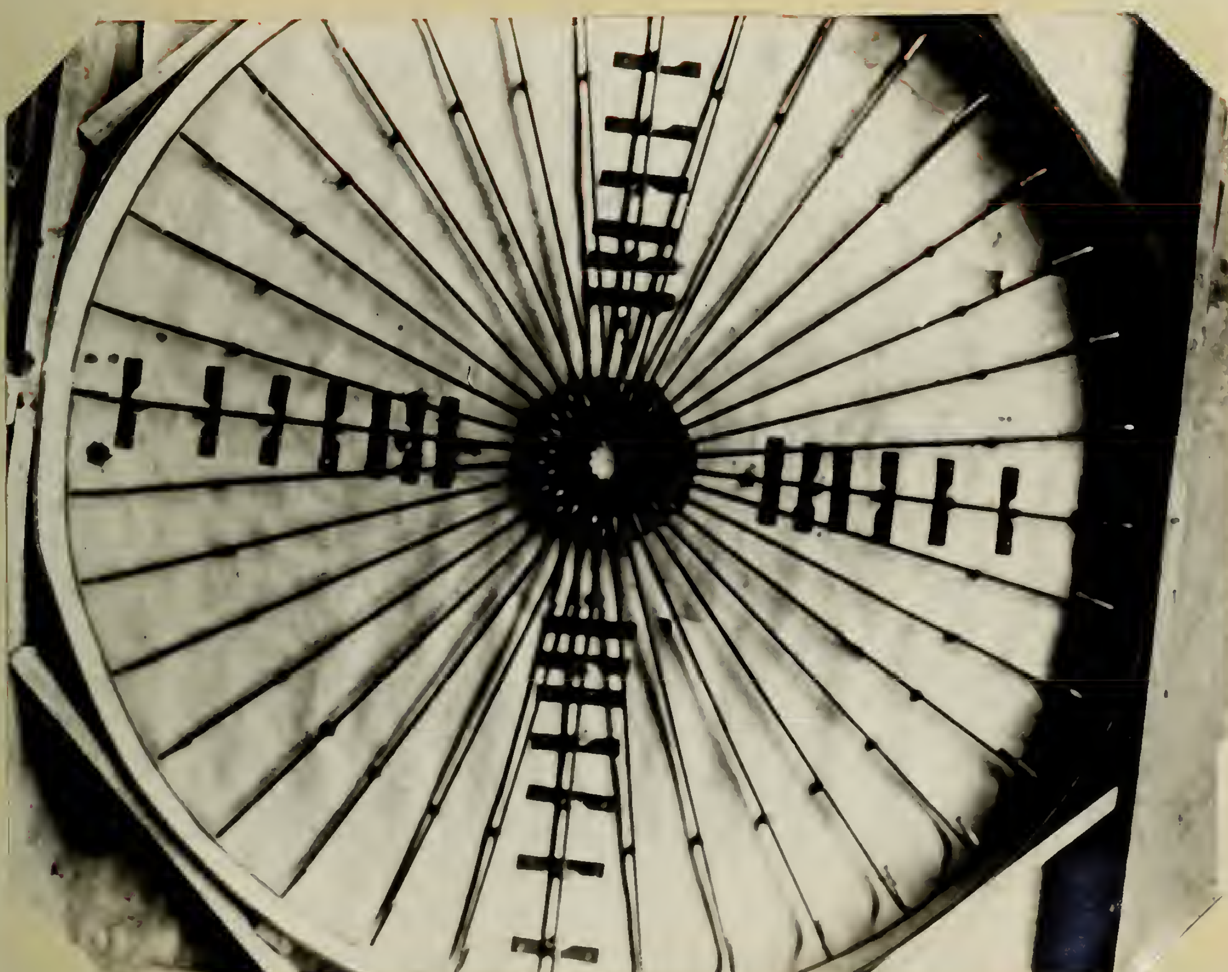


Fig.10. Slab 1243.-View of Reinforcement.

Fig.11. Slab 1245.-View of Forms and Reinforcement.

hooked through a steel plate. The arrangement is clearly shown in Figs.10 and 11 and needs no special description. The holes through the plate just large enough for a driving fit for the rods were drilled at equal intervals on 5 and 6-in. circles. The rods were driven through the holes and bent over about $1\frac{1}{2}$ in., an attempt being made to bend them in such a way as to drive the metal into the holes to fill them as much as possible. It had been the intention not only to hook the rods through the plate but to weld them securely with the blow-torch, but at the time the specimens were made no oxygen was available and the work could not be done in a blacksmith's forge. It is unfortunate that the connections could not be welded as planned for the rods slipped in the plate to a certain extent under test. All the radial rods were bent through 180 degrees on a 4-in. circle at their outside ends with the steel extending to a distance of about 1 inch from the circumference of the slab. In slab 1247 with two layers of reinforcing rods placed at right angles, the ends of the rods were hooked in a manner similar to that just described.

After the forms were in place the location of the reinforcing rods and gage points was marked out on the building paper. Corks of the proper length to insure a depth of $5\frac{3}{4}$ in. from the top to the center of gravity of the steel were placed at the points previously marked where steel readings were to be taken, and the steel placed carefully into position supported on the corks. The use of corks to produce the desired holes in the concrete to make the steel reinforcement accessible was tried this year for the first time at the laboratory. Their use proved very successful

as they came out easily and left a smooth round tapering hole 1 in. in diameter at the surface. In the first slab made the corks were placed on the paper singly and an attempt was made to stick them in position with mucilage. Later two corks 6 in. apart were tacked to a strip of card board before being placed in position. The latter method proved very satisfactory as the corks had added stability. In slabs 1243 and 1244 which contained no circumferential reinforcement nail heads with about an inch of shank were used for gage points, the heads being held in position while placing the concrete by driving the shanks through strips of card board in a manner similar to that in which the corks were held. Fig.10 shows plainly the position of the card board strips with the nails sticking through them.

After the steel had been placed the concrete was put into place with shovels, care being taken to keep from disturbing the corks and to get the concrete into the best possible contact with the steel. No trouble was experienced later from the corks having been moved. When about 3 inches of concrete had been put in, the mass was tamped thoroughly with a small rod and gone over with a light tamping-iron. Next the surface of the forms the concrete was spaded with a trowel. When the forms were full the concrete was tamped with a rather heavy iron and the surface levelled with a straight-edge. For the purpose of taking readings on the upper or compression side plugs of 3/8-in. round rod about 3/4 in. long were embedded flush with the surface of the slab, a templet being used to insure their accurate placement. A few nail heads with about 1 inch of shank were also tried but proved less satisfactory than the pieces of rod. Finally the exposed

surface of the slab was troweled smooth.

The capitals were placed on the slabs the next day after pouring the flat portion to allow the concrete of the latter to set sufficiently to prevent its being pushed out from the added pressure of the concrete above. Short rods previously placed in the flat portion of the slabs and extending into the capitals were used to avoid any possibility of the capitals coming loose.

8. Auxiliary Specimens.- From the concrete used in each specimen three 6-in. cubes, one 8 by 16-in. cylinder, and one 6 by 8-in "control beam" 40 inches long were made. These were stored in damp sand. About the time the corresponding slab was due the cubes and cylinders were removed to the testing laboratory and two faces prepared for the test by the addition of a thin coat of plaster of paris. Table 6 gives the results of compression tests on the cubes and cylinders.

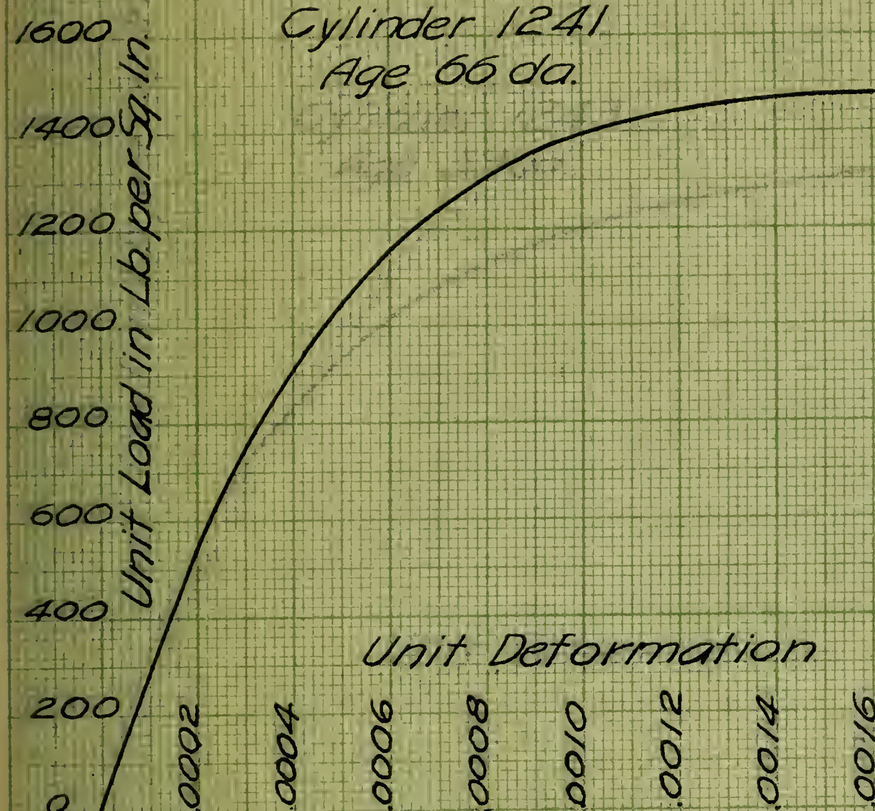
Table 6.

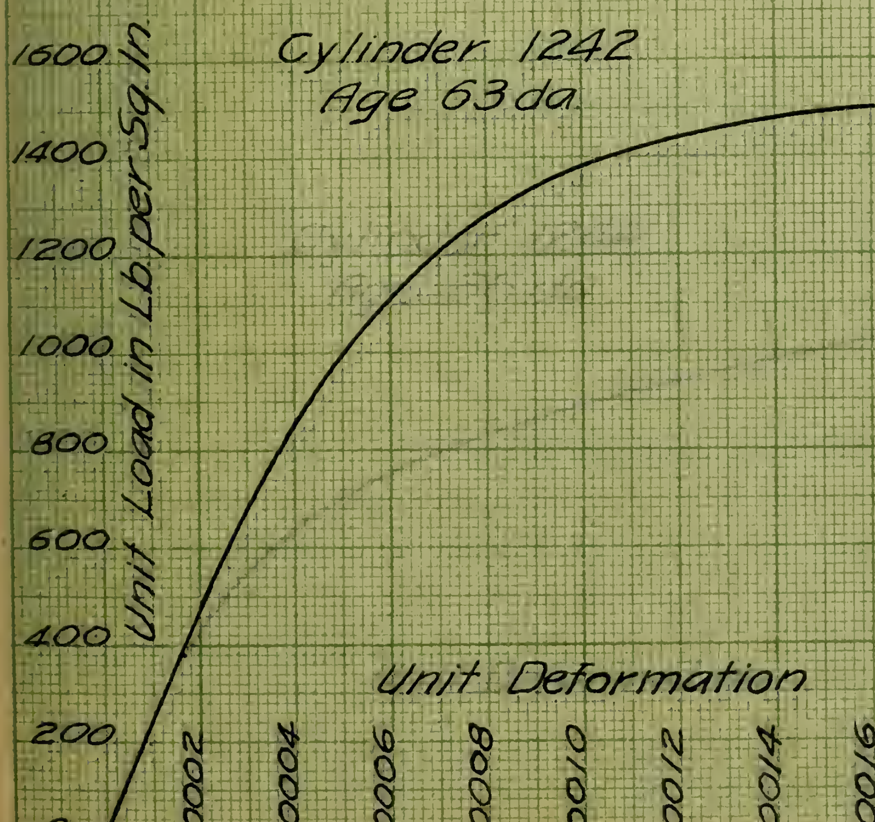
COMPRESSION TESTS OF CUBES AND CYLINDERS.

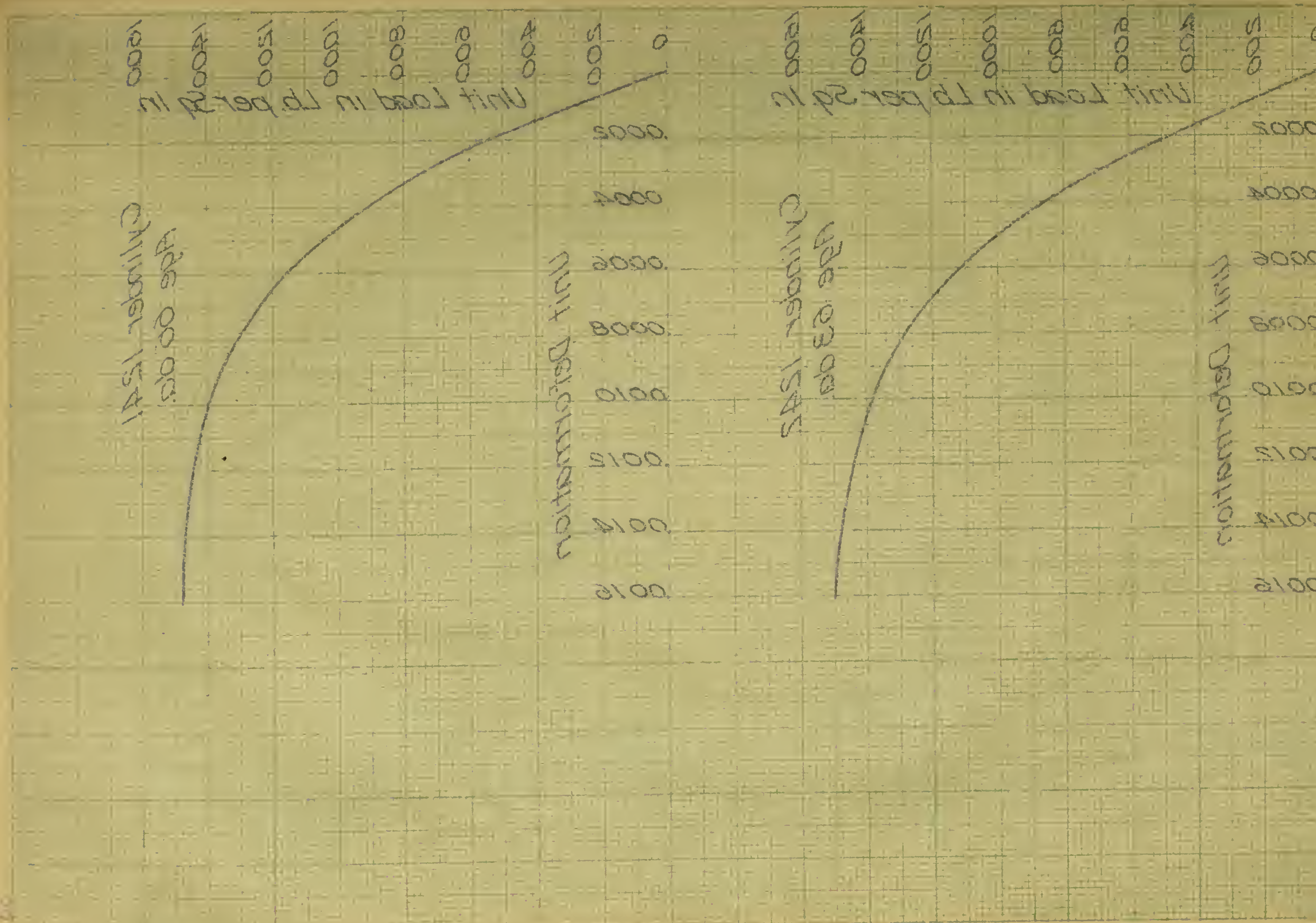
Maximum Loads given in lb. per sq. in.

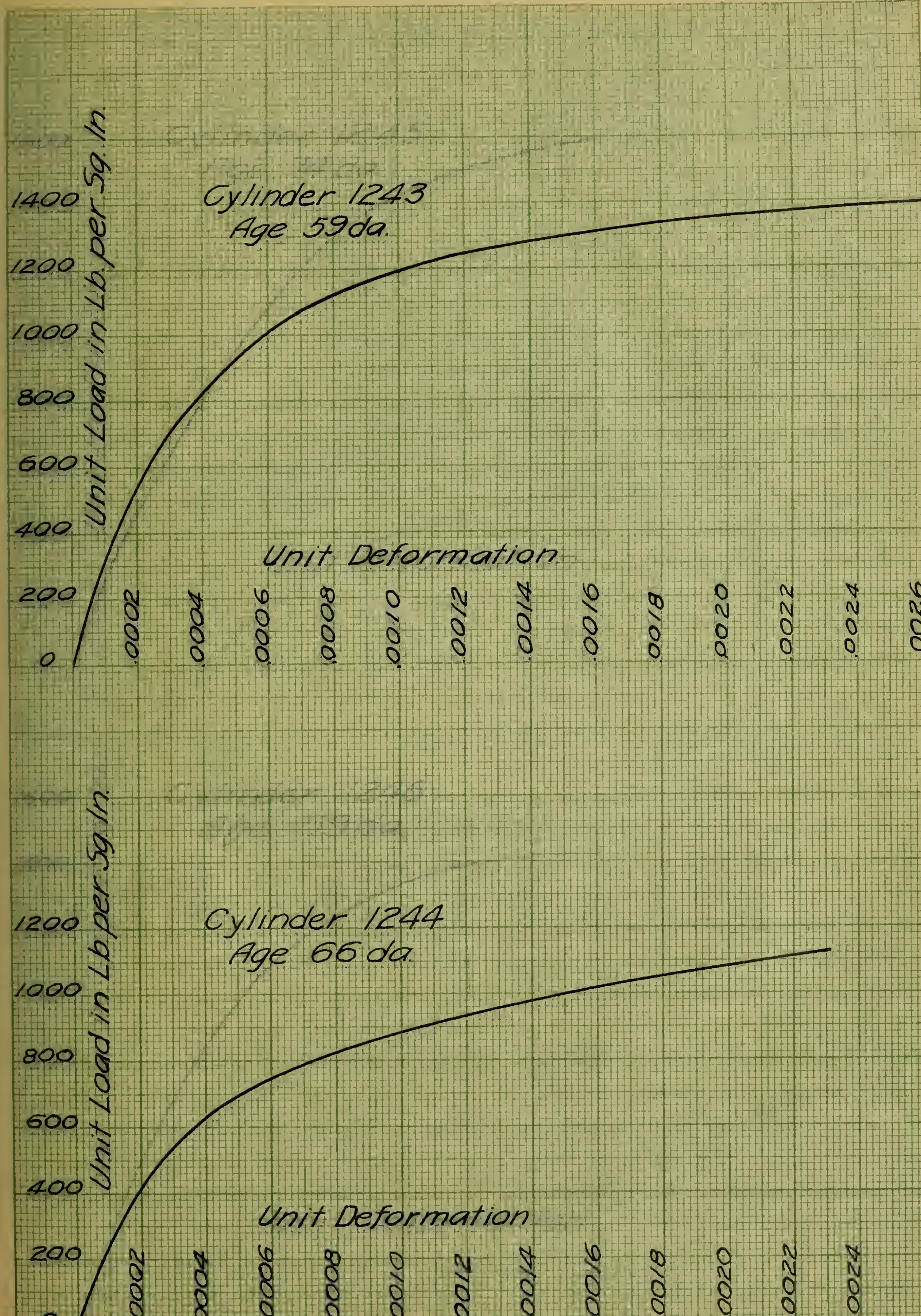
Slab No.	Cubes		Cylinders	
	Age da.	Max. Load	Age da.	Max. Load
1241	66	1815	66	1470
1242	63	1975	63	1495
1243	59	1550	59	1390
1244	65	2060	66	1125
1245	73	2600	74	1605
1246	59	1840	59	1430
1247	70	1865	70	1330

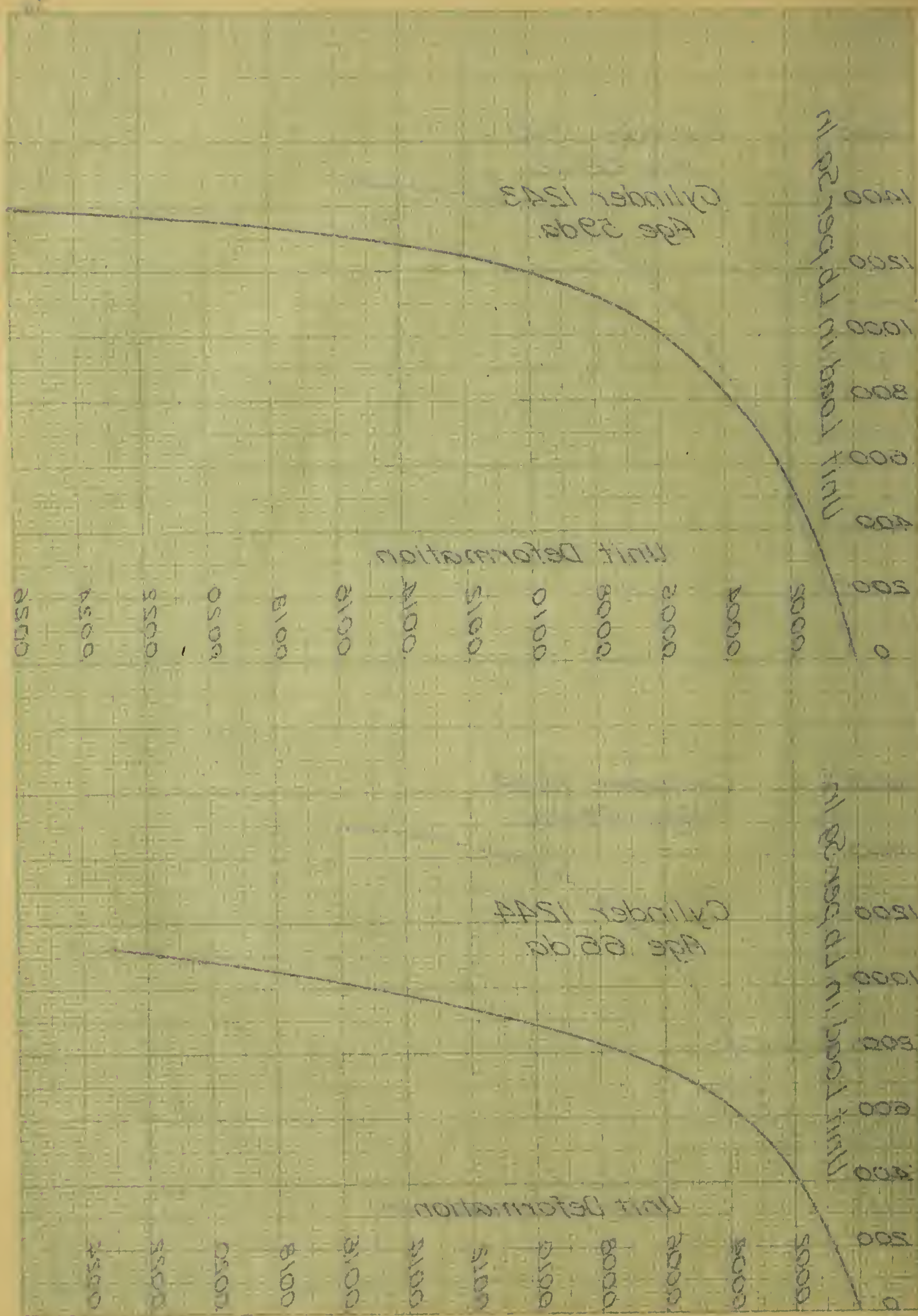
The results show rather low values for the cubes tested when due at the end of 60 days with increasing strength for those tested


Cylinder 1241
Age 66 da.
Unit Load in Lb. per Sq. In.
1600
1400
1200
1000
800
600
400
200
0
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016

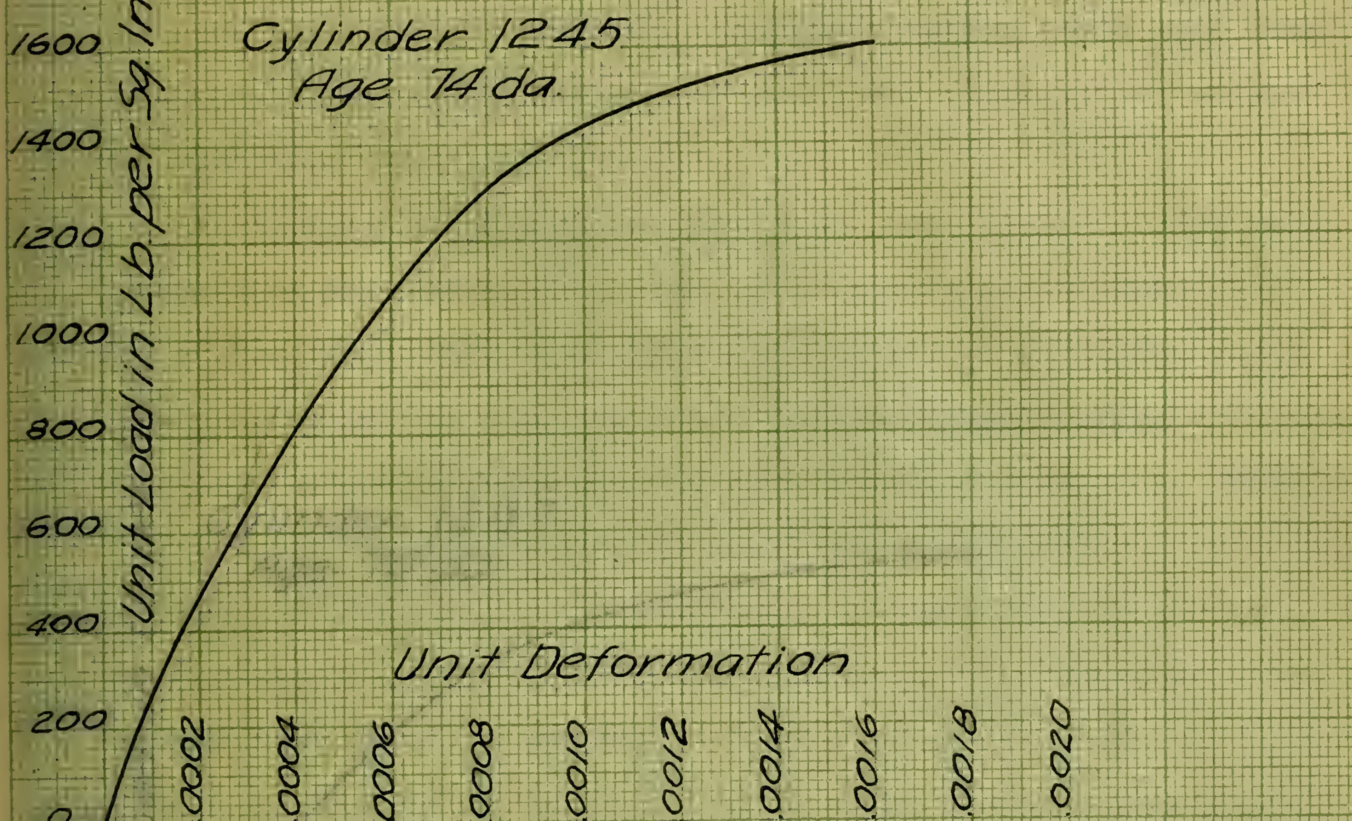

Cylinder 1242
Age 63 da.
Unit Load in Lb. per Sq. In.
1600
1400
1200
1000
800
600
400
200
0
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016

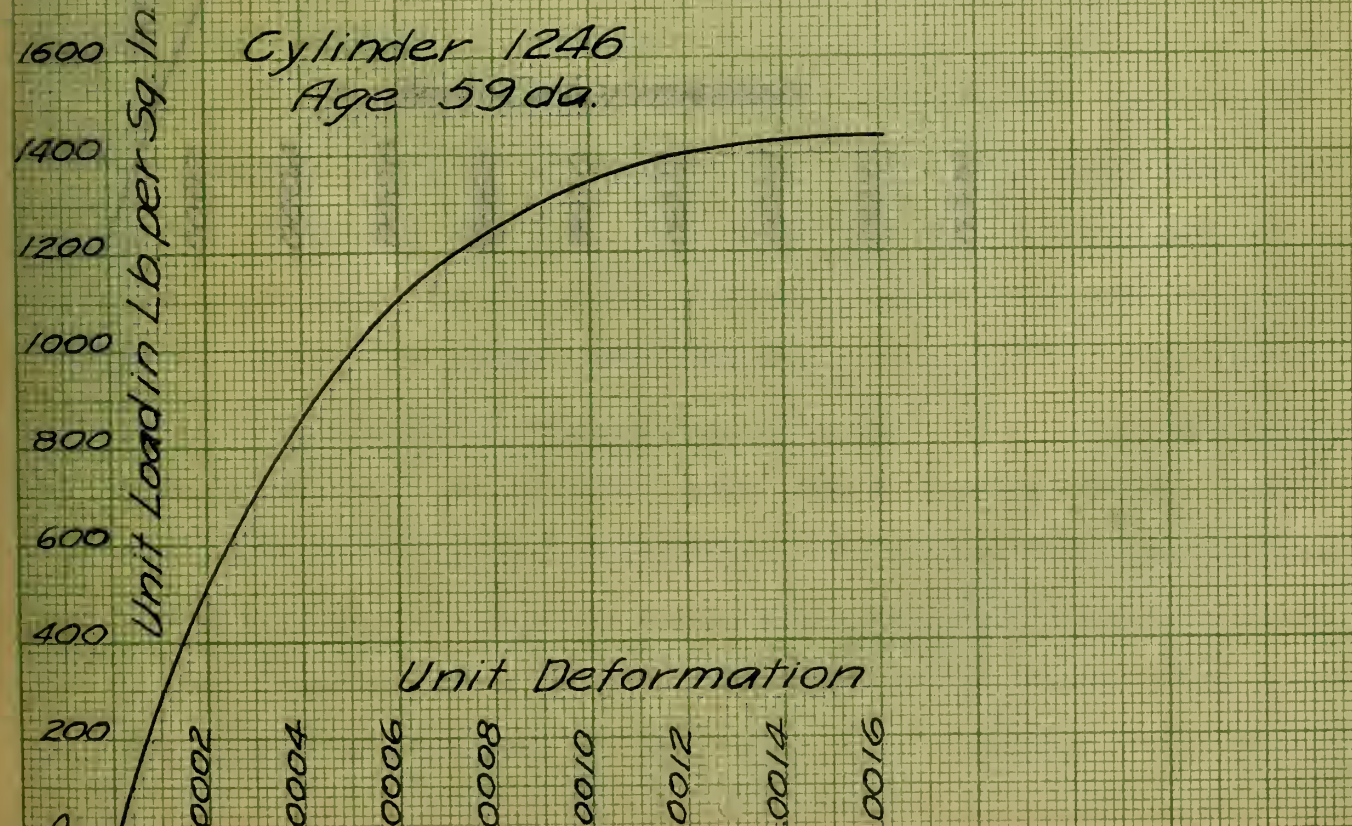

Unit Load in Lb per Sq In
Cylinder 1241
Age 60 da.
Unit Deformation
Unit Load in Lb per Sq In
Cylinder 1242
Age 63 da.
Unit Deformation

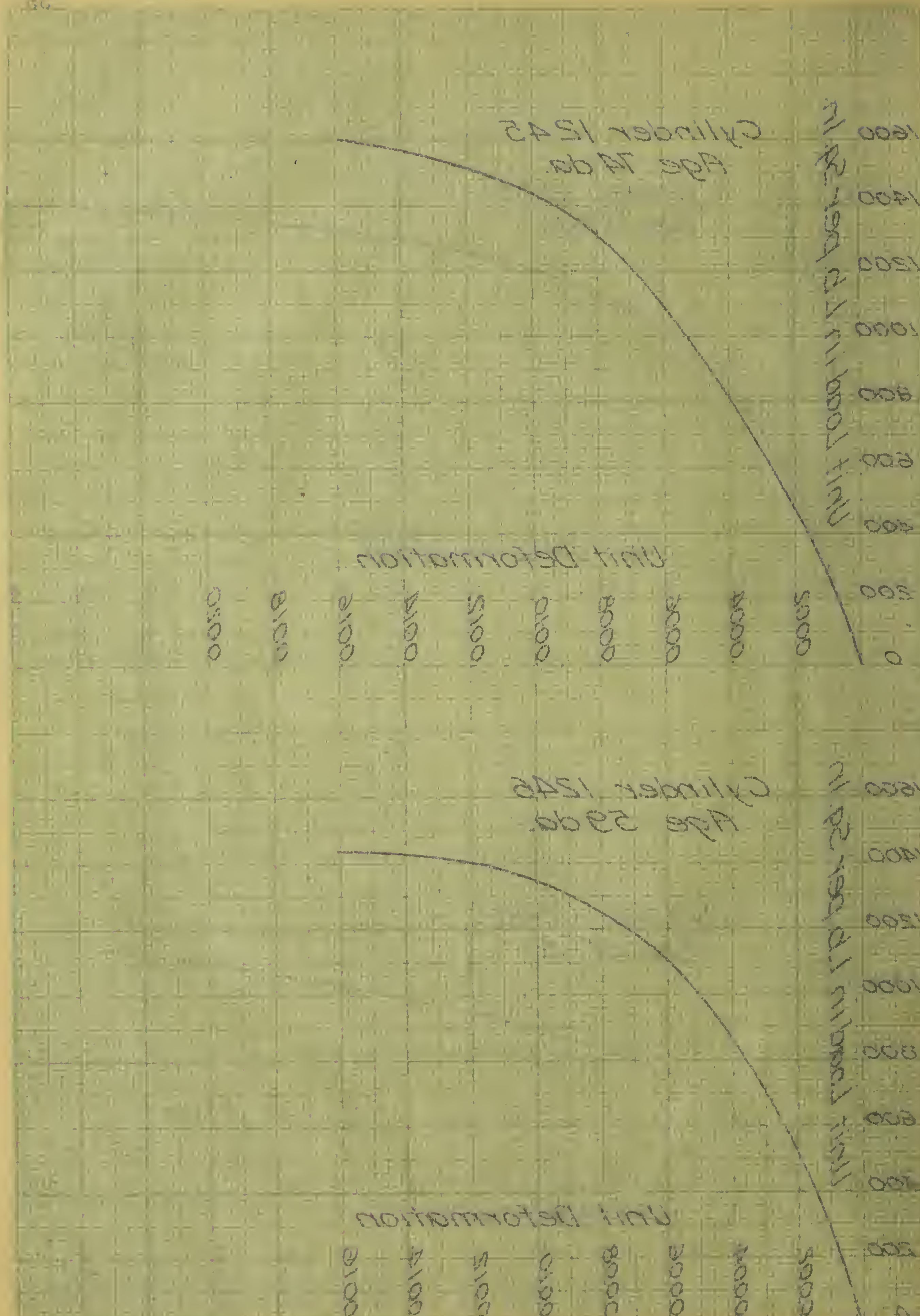

Cylinder 1243
Age 59 da.
Unit Load in Lb. per Sq. In.
0
200
400
600
800
1000
1200
1400
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020
.0022
.0024
.0026
Cylinder 1244
Age 66 da.
Unit Load in Lb. per Sq. In.
0
200
400
600
800
1000
1200
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020
.0022
.0024



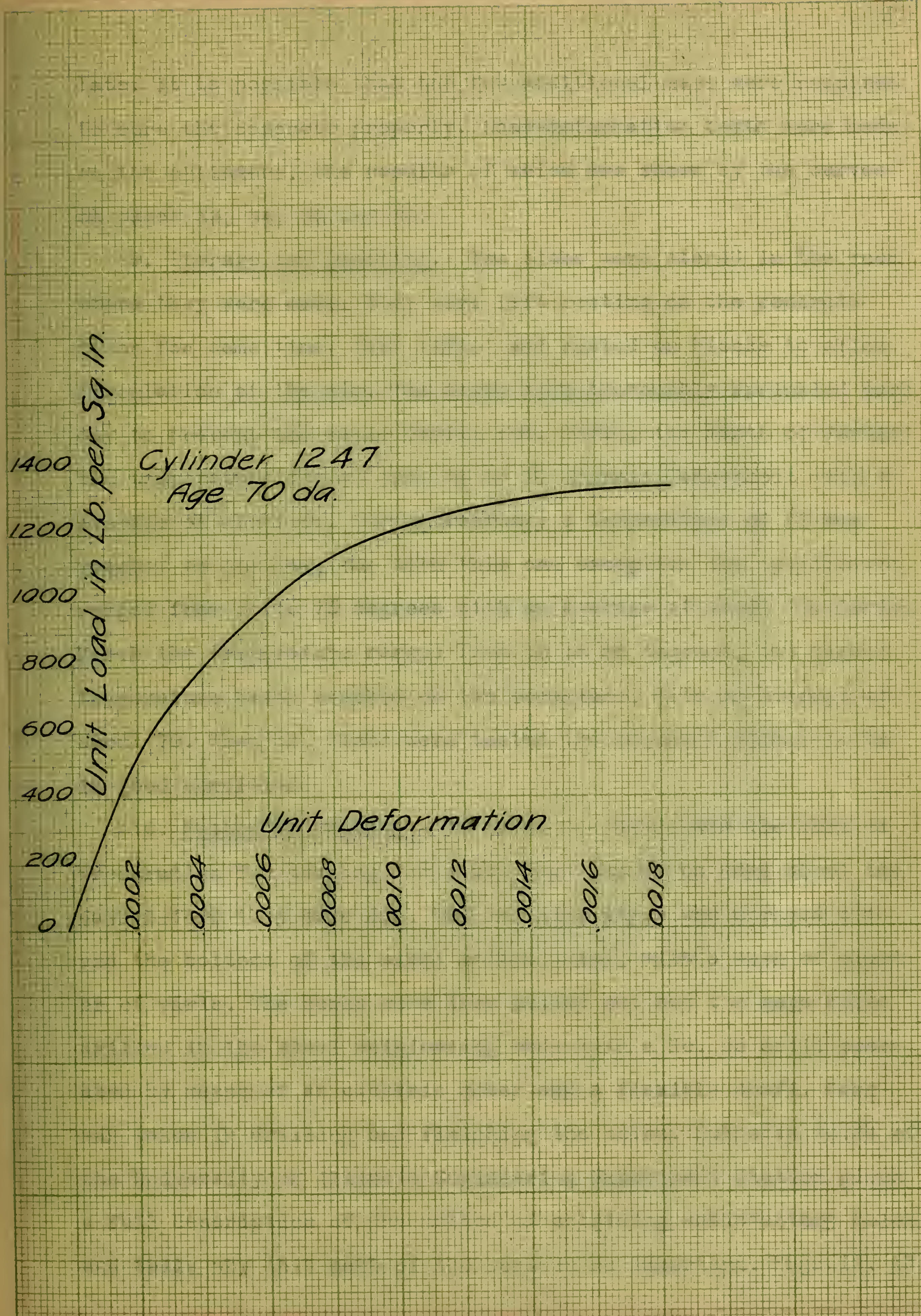
Cylinder 1243
Age 59 da.
Unit Load in Lb per Sq In
Unit Deformation
Cylinder 1244
Age 65 da.
Unit Load in Lb per Sq In
Unit Deformation

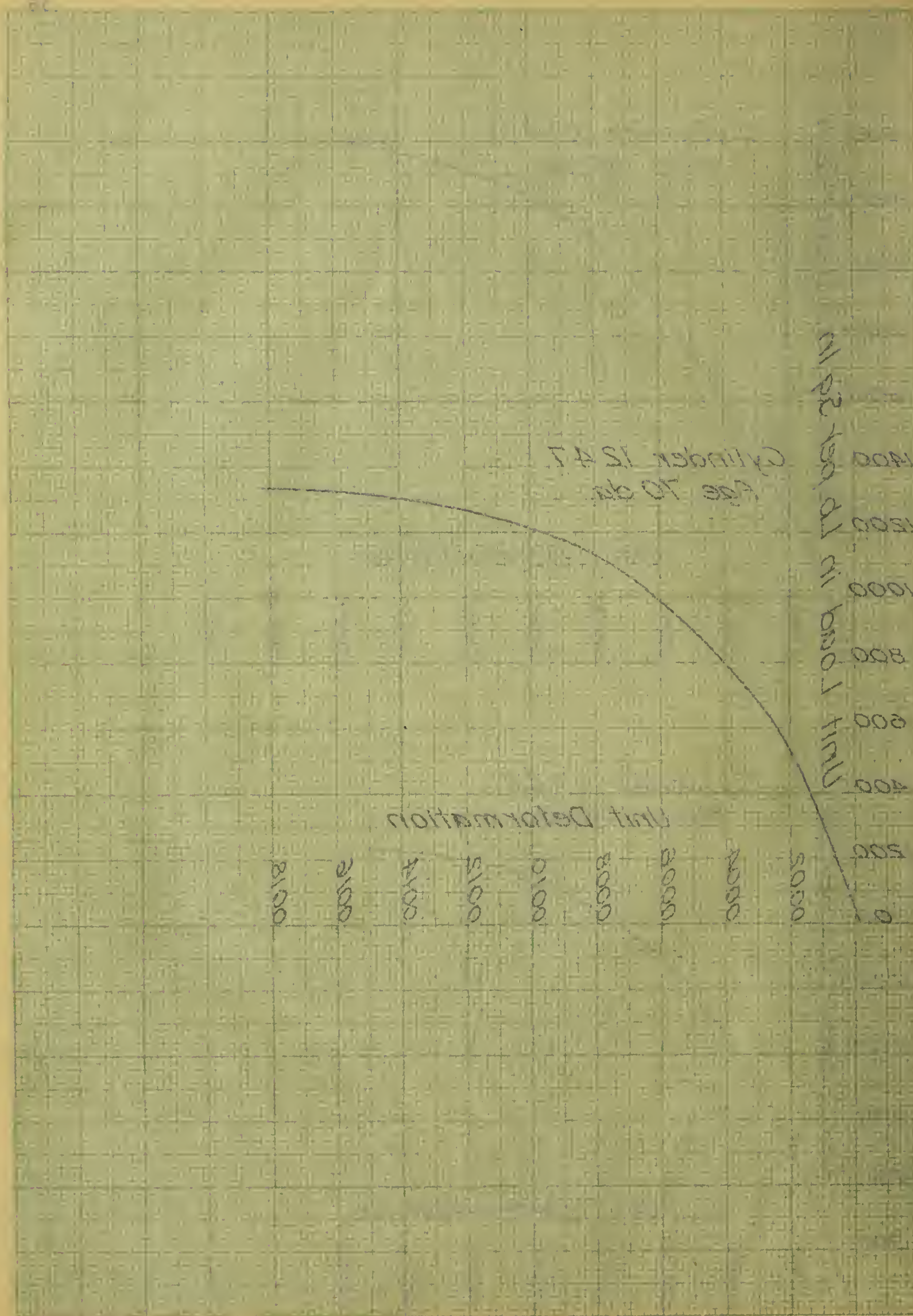

Cylinder 1245
Age 74 da.
Unit Load in Lb. per Sq. In.
1600
1400
1200
1000
800
600
400
200
0
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020


Cylinder 1246
Age 59 da.
Unit Load in Lb. per Sq. In.
1600
1400
1200
1000
800
600
400
200
0
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016



Cylinder 1245
Age 74 da.
Unit Load in Lb per Sq. In
Unit Deformation
0
200
400
600
800
1000
1200
1400
1600
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020
Cylinder 1246
Age 59 da.
Unit Load in Lb per Sq. In
Unit Deformation


Cylinder 1247
Age 70 da.
Unit Load in Lb. per Sq. In.
1400
1200
1000
800
600
400
200
0
Unit Deformation
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018


Cylinder 12 4 7
Age 70 da
Unit Load in Lb per Sq In
0
200
400
600
800
1000
1200
1400
Unit Deformation
0.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018

late. It is possible that the few additional days were required to cure the concrete properly. Load-deformation tests were made on the cylinders, the results of which are shown by the curves on pages 33, 34, 35 and 36.

9. Storage and Handling.- The slabs were stored in the room where they were made. They were left resting on the concrete floor for some time, then lifted and rested on blocks to allow circulation of the air. The slabs were thoroughly sprinkled each day to prevent too rapid drying out. During the month of January the temperature ranged from 55 to 70 degrees Fahrenheit with an average of about 65. During February a temperature of 52 was reached on one day, but with this one exception the temperature ranged from 55 to 75 degrees with an average of about 70. During March the temperature ranged from 58 to 80 degrees, the higher temperature being reached on two occasions, with an average of about 70. When the slabs were tested the concrete seemed to be in good condition.

10. Method of Testing.- In order to facilitate the work of preparation for testing the slabs were turned on edge about two days before they were due. The building paper was scraped off and the bottoms of the slabs coated thinly with a wash of plaster of paris. The corks were then pulled out and the gage holes drilled in the steel reinforcing rods with a No. 55 drill operated by means of an electric motor and a flexible shaft. Care was taken in drilling and finishing the holes. Bulletin No.64 of the University of Illinois Engineering Experiment Station gives a full description of the method of obtaining satisfactory holes and tells why this part of the work is so important. Figs.12, 13,

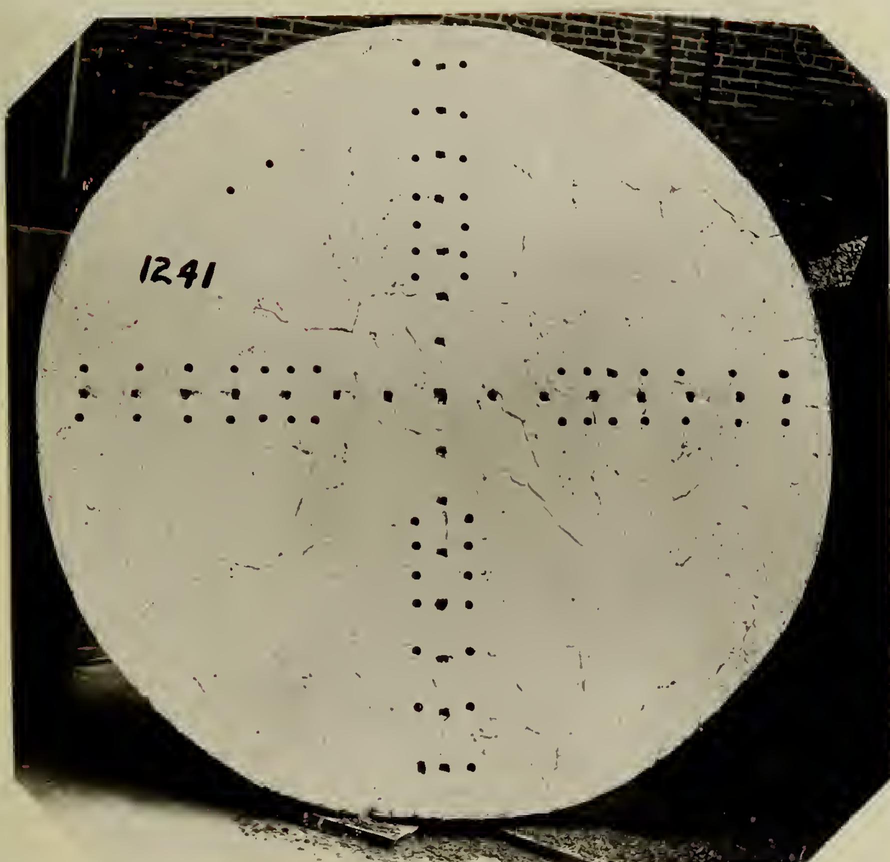


Fig.12. Slab 1241.-View of Bottom of Slab before Test.

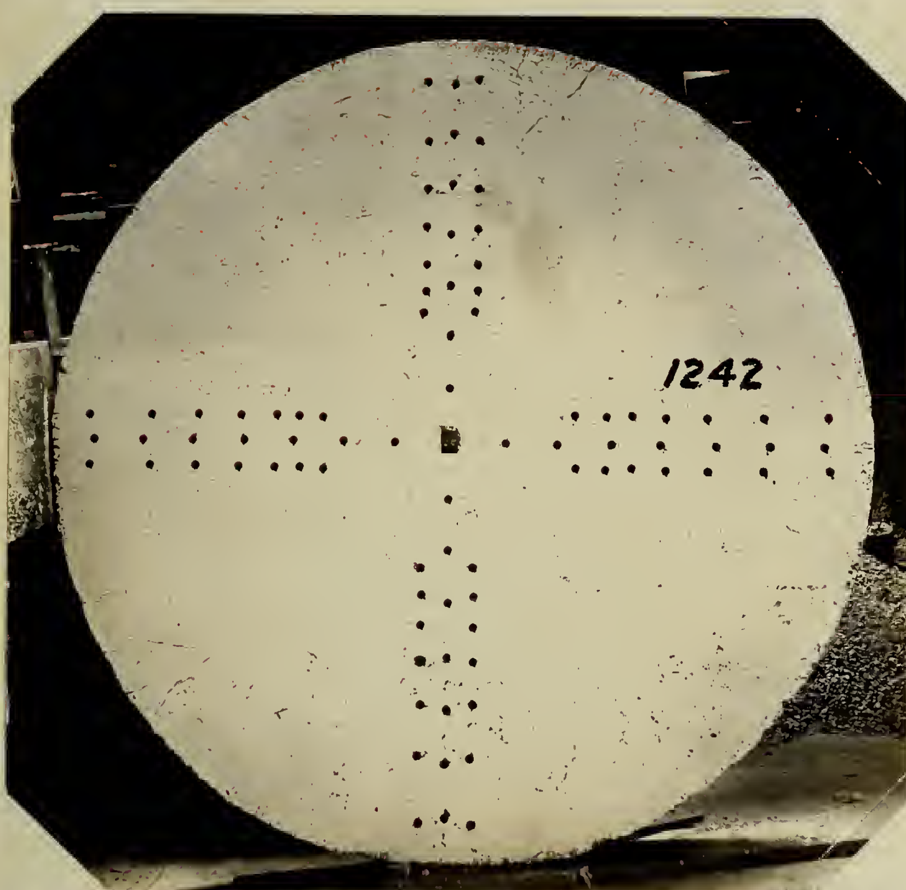


Fig.13. Slab 1242.-View of Bottom of Slab before Test.

Fig.14. Slab 1244.-View of Bottom of Slab before Test.

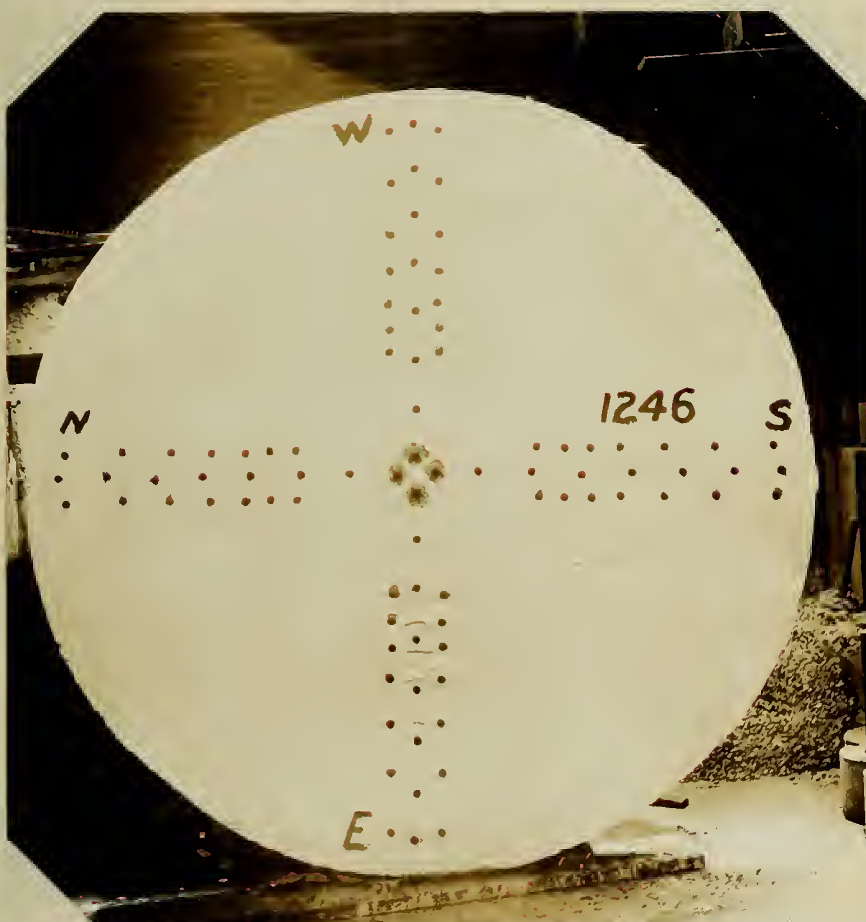


Fig.15. Slab 1246.-View of Bottom of Slab before Test.

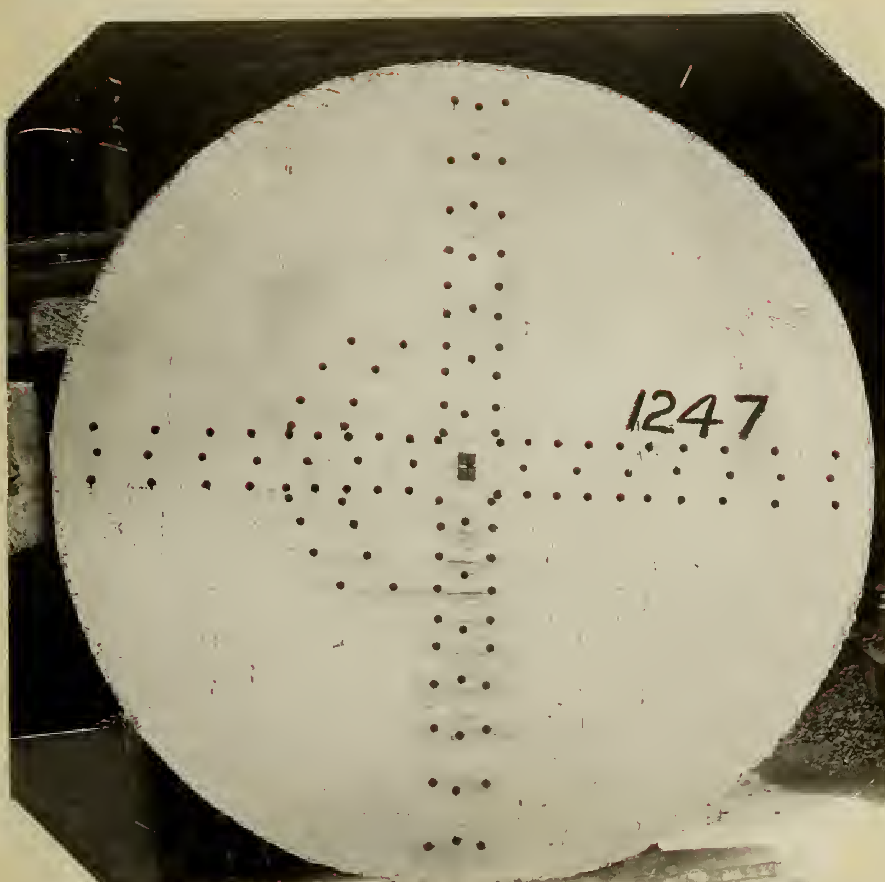


Fig.16. Slab 1247.-View of Bottom of Slab before Test.

14, 15, 16 show the appearance of five of the slabs after the bottoms had been prepared for testing. The specimens were next righted and the gage holes drilled in the plugs inserted in the upper or compression side. A crane (see Fig. 17) was used to lift the slabs and turn them on edge, four steel loops being bedded in the concrete for that purpose. The placing of these loops was overlooked in slab 1245 and it was handled with large hooks but was not turned on edge. The gage holes on the bottom were drilled with this slab in position on the testing-machine,and those farthest from the center both radially and circumferentially could not be drilled as the construction of the testing-machine would not allow access to them.

The testing-machine consisted of a heavily reinforced concrete base with a hollow interior, a 24" - 100# I-beam to take the thrust, and four steel rods connecting the I-beam with the base. Fig. 19 gives the dimensions of the concrete base and the general appearance of the machine is well shown in Fig. 18. 72 - 7-in. springs about 3 in. in outside diameter composed of $\frac{1}{2}$-in. round spring steel were placed at equal intervals on a 7-ft. - 6-in. circle and used to support the slabs. The slabs rested directly on 4 by 4 by $\frac{1}{2}$-in. plates with $1\frac{1}{2}$-in. cylindrical plugs 2 in. long extending into the springs to keep the plates in place. Due to the slightly unequal lengths of the springs and a little warping of the bottoms of the slabs shims were necessary to insure a uniform bearing on the springs. The specimens were centered in the machine with the tension sides down and the load applied to the capital through a plate resting on a thin bed of plaster of paris. A 100-ton hydraulic jack was used to apply the

Fig.17. View Showing Method of Handling Slabs.

Fig.18. View Showing Testing-machine with Slab in Place.

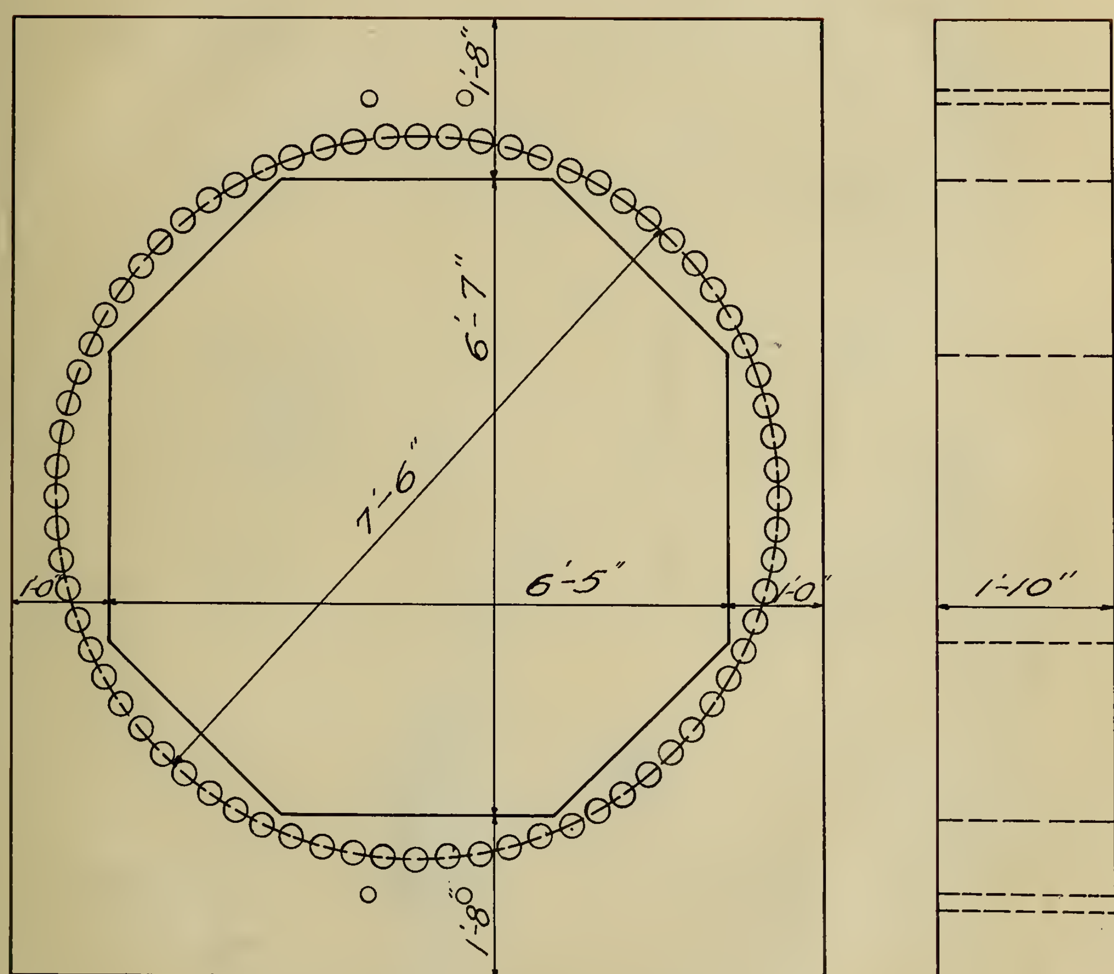


Fig.19. Concrete Base of Testing-machine

Showing Location of Springs to Support Slab.

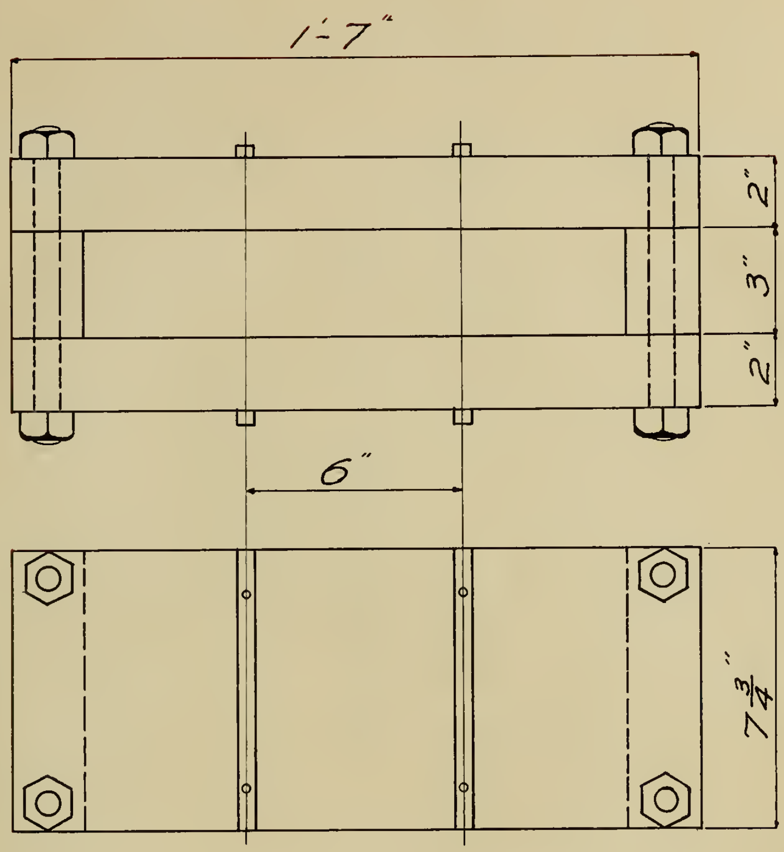


Fig.20. Dimensions of Dynamometer.

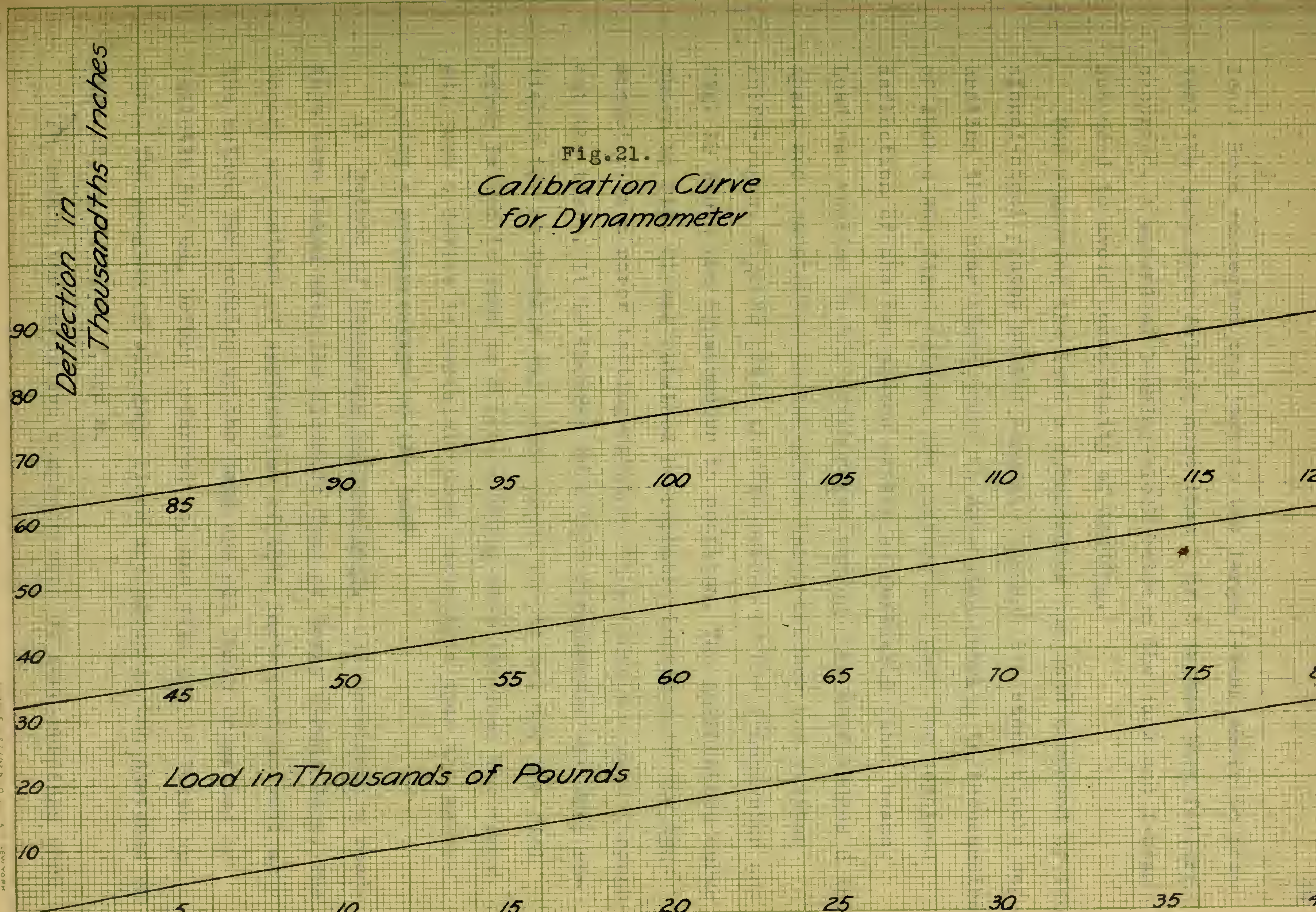
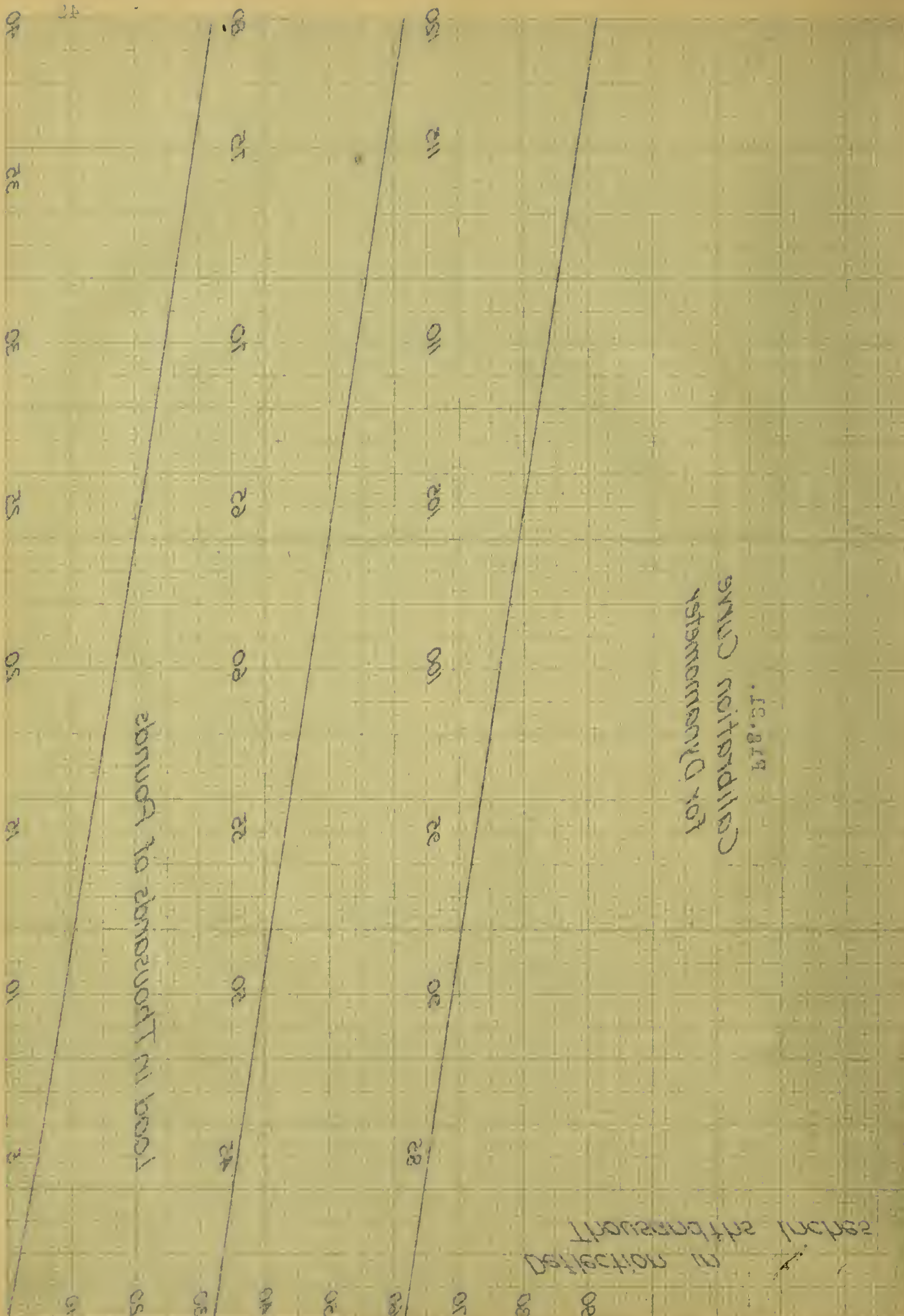


Fig.21.
Calibration Curve for Dynamometer


Calibration Curve
for Dynamometer
Fig. 21.
Load in Thousands of Pounds
Deflection in
Thousandths Inches

load. Rods connected the jack to the large I-beam above to prevent the jack from falling more than 2 or 3 inches when failure occurred. A spherical bearing-block between the jack and I-beam was used to avoid eccentricity of loading.

For measuring the load a dynamometer was used composed of two nickel-steel plates bolted securely through two steel blocks separating them near their ends. An Ames dial reading to thousandths of inches was fixed between the plates, and gave the combined deflection of the two plates acting as partially fixed beams. Load was applied to the dynamometer through two knife-edges 6 in. apart and transferred to the plate below through two similar knife-edges. Fig. 20 gives the dimensions of the dynamometer and fig. 18 shows the dynamometer in position. The calibration curve shown in Fig. 21 was obtained by repeated loadings of the dynamometer in a screw testing-machine. This curve was used throughout the tests. It is thought that this dynamometer was very reliable for no trouble was experienced in its use and the dial never failed to come to a zero reading when the load was romoved. Such a device is certainly more dependable than the scheme of using a pressure-gage on the jack.

11. Method of Measuring Deformations.- All deformation readings were taken with the Illinois Type of Berry Strain Gage. The theory and method of application of this instrument as well as the method for working up the data are all fully described in bulletin No. 64, before referred to, and will not be taken up here. The lengths of all gage lines are given in the sketches of Figs. 2, 3, 4, 5, 6, 7, and 8.

In making the tests two complete sets of zero readings were

taken with no load applied. These observations were reduced and in case of very much disagreement between the two observations for any gage line a third observation was taken. Load was then applied in increments of 5 000 and 10 000 lb. and a complete set of observations taken for each increment until failure occurred. One observer took observations on the tension side under the slab while a second observer was working on the upper or compression side. About fifty observations, including those on the standard-bar, were required of the observer above and from sixty to ninety of the observer below. After each increment of load cracks were searched for and marked with a pencil on the surface of the plaster of paris coating, together with the load at which each crack appeared. The plaster coat enabled the cracks to be seen when they were very minute and at a very much earlier period than would have been the case had the concrete surface been left bare. A complete set of observations could be taken and the cracks marked usually in three-quarters of an hour. The observations obtained were reduced and corrected after the actual test had been completed.

III. EXPERIMENTAL DATA AND DISCUSSION

III. EXPERIMENTAL DATA AND DISCUSSION.

12. Data.- In Table 7 are given the maximum loads carried by the test slabs.

Table 7.

MAXIMUM LOADS CARRIED BY SLABS.

Slab No.	Made	Tested	Age da.	Maximum Load lb.
1241	Jan. 4, 1913	Mar. 5, 1913	60	35 000
1242	Jan. 25, 1913	Mar. 26, 1913	60	33 000
1243	Jan. 11, 1913	Mar. 10, 1913	58	50 000
1244	Jan. 22, 1913	Mar. 24, 1913	61	50 000
1245	Jan. 14, 1913	Mar. 15, 1913	60	62 500
1246	Jan. 29, 1913	Mar. 31, 1913	61	70 000
1247	Jan. 18 1913	Mar. 20, 1913	61	78 000

Load-deformation diagrams for all gage lines are given on pages 128 to 184. The distance of each gage line from the center of the slab can be obtained from the position of the axis denoting zero unit deformation. On pages 60, 61, 64, 65, 73, 74, 77, 78, 87, 88, 91, 92, 100, 101, are given load-deformation diagrams with unit deformations obtained by averaging values of the results for gage lines located symmetrically with respect to the center. For example, the unit deformations on the four gage lines marked N-7, E-7, S-7, W-7, which were placed circumferentially and the same distance from the center have been averaged and appear in the curve marked 7. On pages 62, 63, 66, 67, 75, 76, 79, 80, 89, 90, 93, 94, 102, 103, the average unit deformations appear as ordinates with the distances from the center as abscissas, a curve being plotted for each test load for which observations were taken. Figs. 23, 25, 27, 29, 30, 33, and 36

show the location of cracks which appeared on the tension sides of the slabs during the tests. A number adjacent to a crack denotes the load in thousands of pounds at which that crack appeared. On pages 186 to 206 are given corrected differences obtained by a reduction of all the strain gage observations, the theory of which is treated in bulletin No. 64 of the University of Illinois Engineering Experiment Station. For the observations on the 6-in. gage lines which comprise all those taken with the exception of those marked B' on specimens 1243 and 1244, the corrected readings must be divided by 30 000 to obtain unit deformations, since the dial of the strain gage read directly to thousandths of inches, the lever-arm was 5 to 1, and the gage lengths were 6 inches. Complete data for all tests are on file in the Laboratory of Applied Mechanics, but as there were more than thirty-five hundred observations only the corrected readings are included in this thesis.

The discussions of the tests will be made under the following heads: A. Slabs with Circumferential Reinforcement Only; B. Slabs with Radial Reinforcement Only; C. Slabs with Circumferential and Radial Reinforcement; D. Slab with Rectangular Form of Reinforcement; E. Summary; F. Theory and Analysis.

A. SLABS WITH CIRCUMFERENTIAL REINFORCEMENT ONLY.

13. Phenomena of Tests.- At a load of 15000 lb. on slab 1241 a few radial cracks formed thru the holes cut into the slab to bare the steel. A crack which showed under a 20 000-lb load, following the outlines of the column capital, was the first circumferential crack to appear. A few others were found at higher

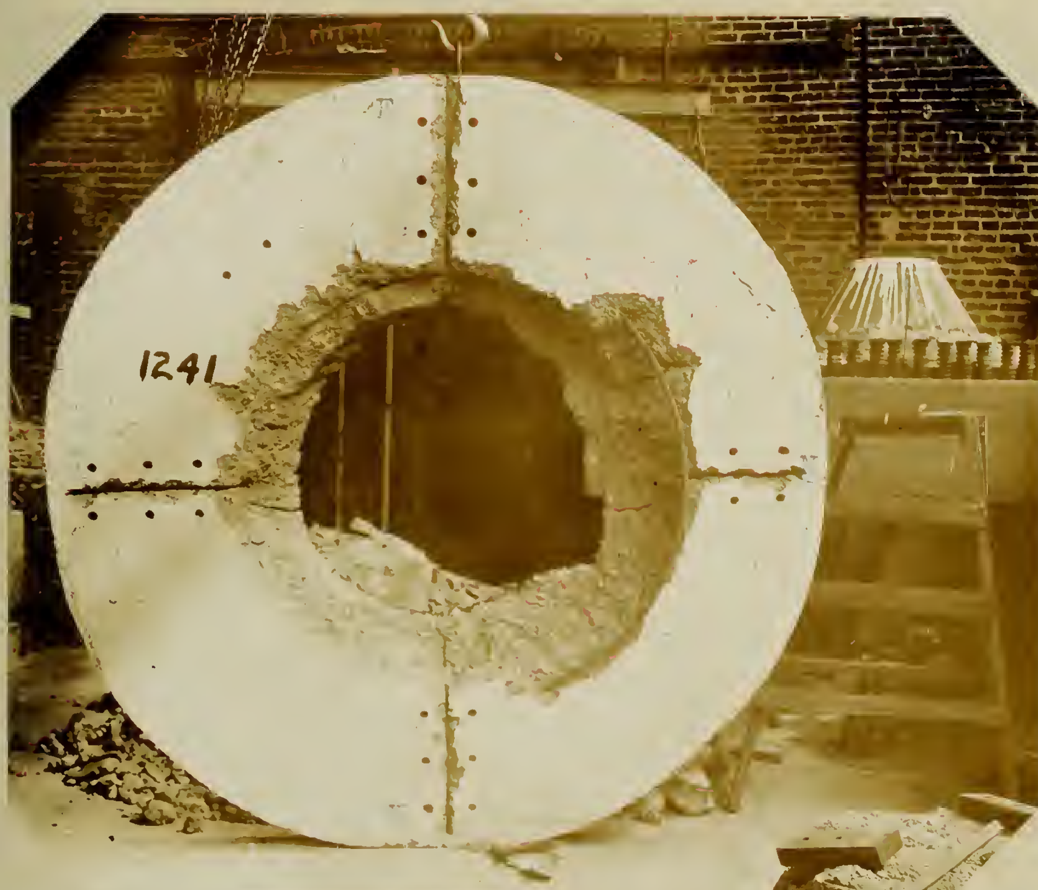


Fig.22. Slab 1241.-View Showing Manner of Failure.

Fig.23. Slab 1241.-Location of Cracks.

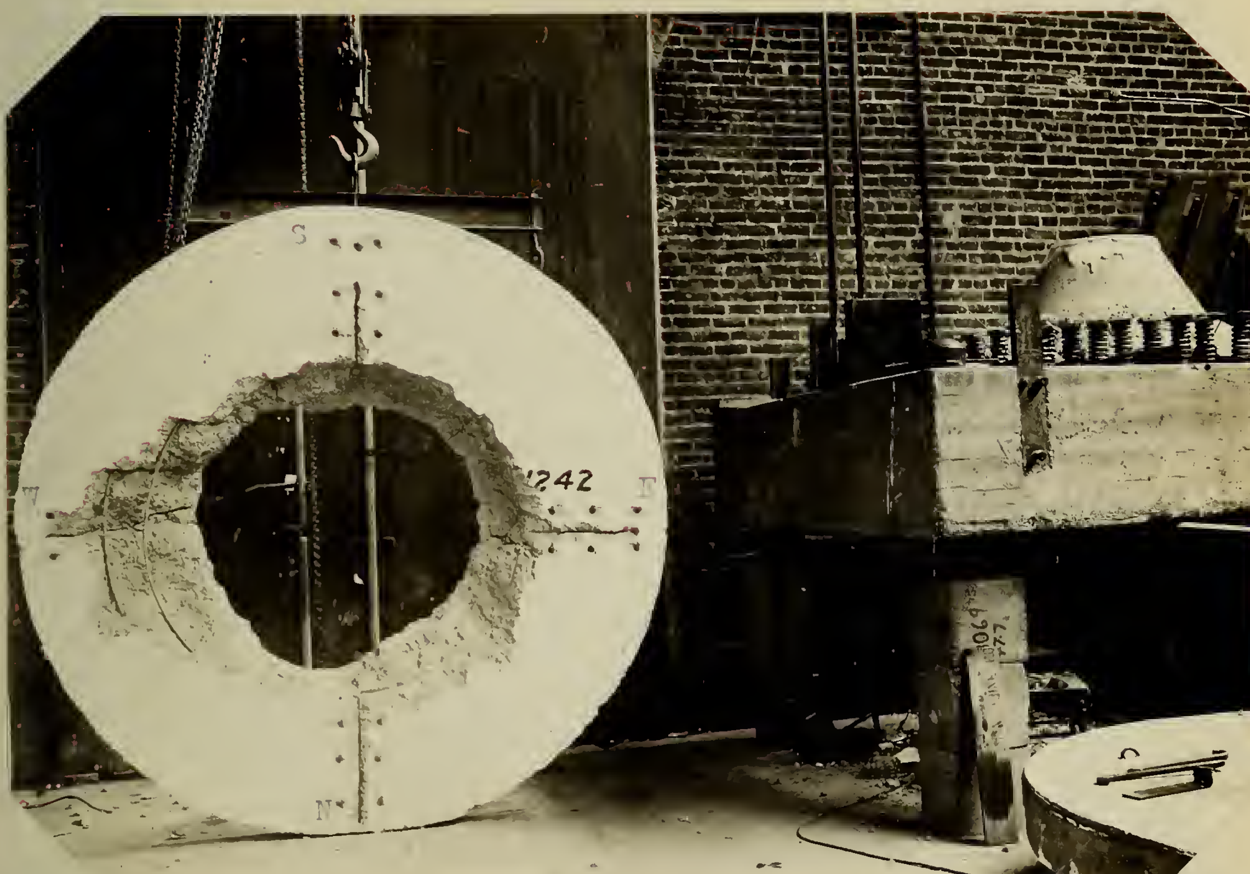


Fig.24. Slab 1242.-View Showing Manner of Failure

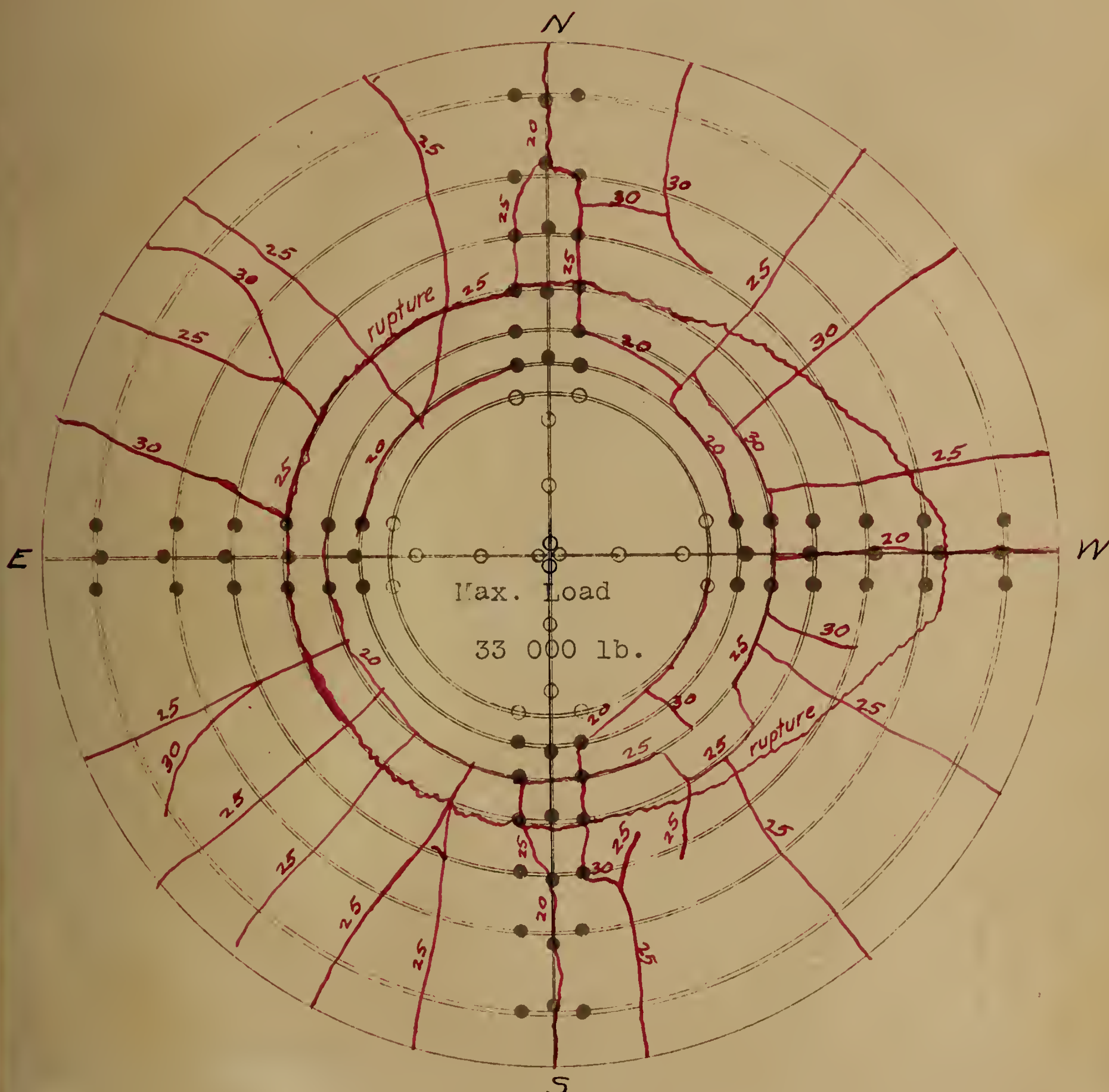


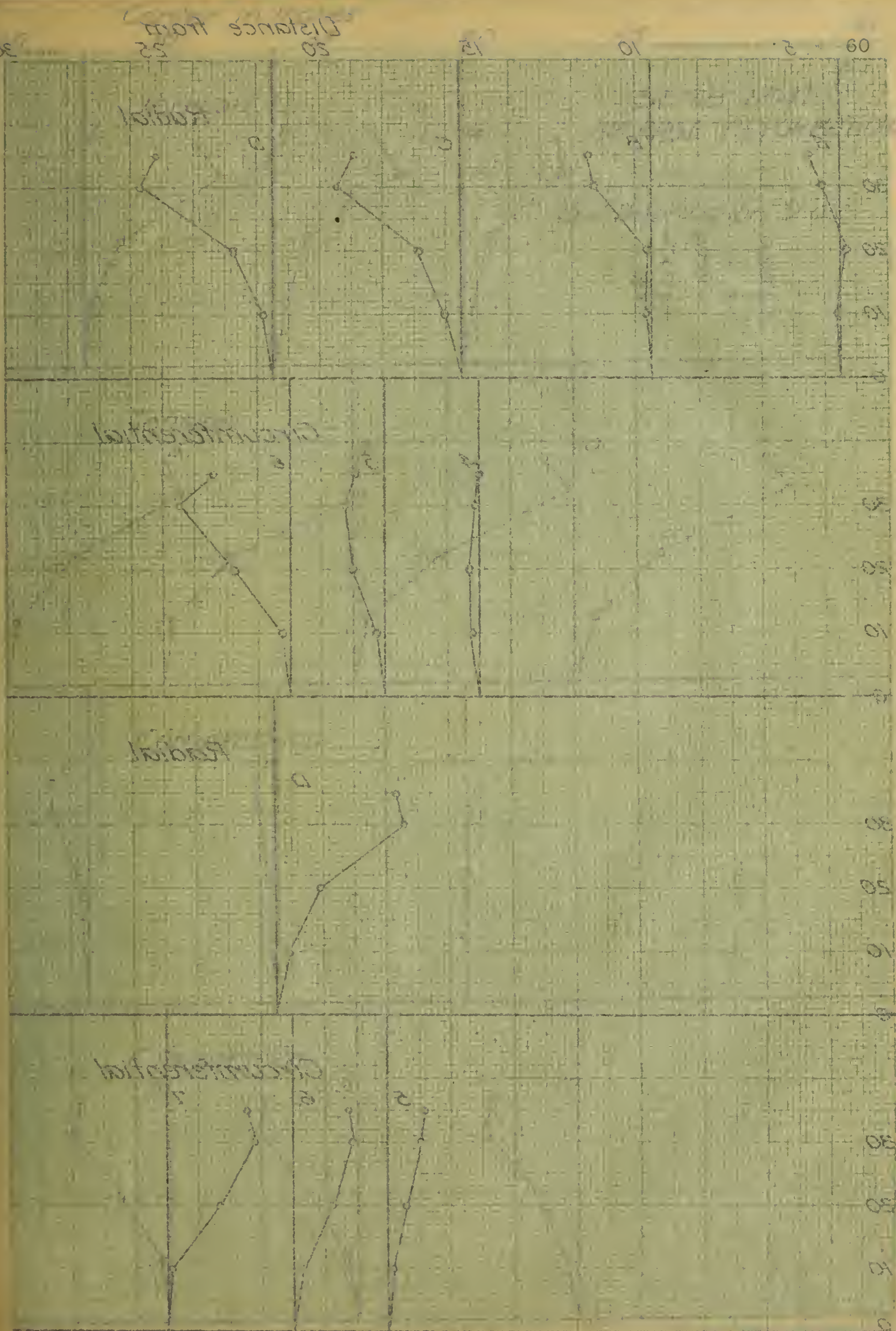
Fig.25. Slab 1242.-Location of Cracks.

loads. At loads of 25 000 and 30 000 lb. radial cracks formed which extended from the outer edge of the slab to the circumferential cracks just mentioned. At 30 000 lb. a circumferential crack which followed the fourth hoop from the center was opening up and gave warning of failure. All circumferential cracks were found to have followed the reinforcing rods quite closely and to extend tangent to the outside perimeters of the hoops. On the inside of each hoop the concrete appeared to be in compression against the surface of the rod. Fig. 23 shows the location of the cracks at this time and the load at which each crack appeared. The radial cracks remained comparatively minute. A load of 35 000 lb. was finally applied, but when a set of observations had been taken the load was found to have fallen off to about half that amount. It is evident that failure had been progressing while the observations were being taken. Rupture occurred before the load could be brought back to 35 000 lb. The section along which rupture took place extended from the edge of the column capital above to the line marked "rupture" in Fig. 23. Fig 22 shows a view of the bottom of the slab after the test. The column capital may be seen resting on the testing-machine, two timbers having been placed to keep it from dropping through to the floor of the laboratory.

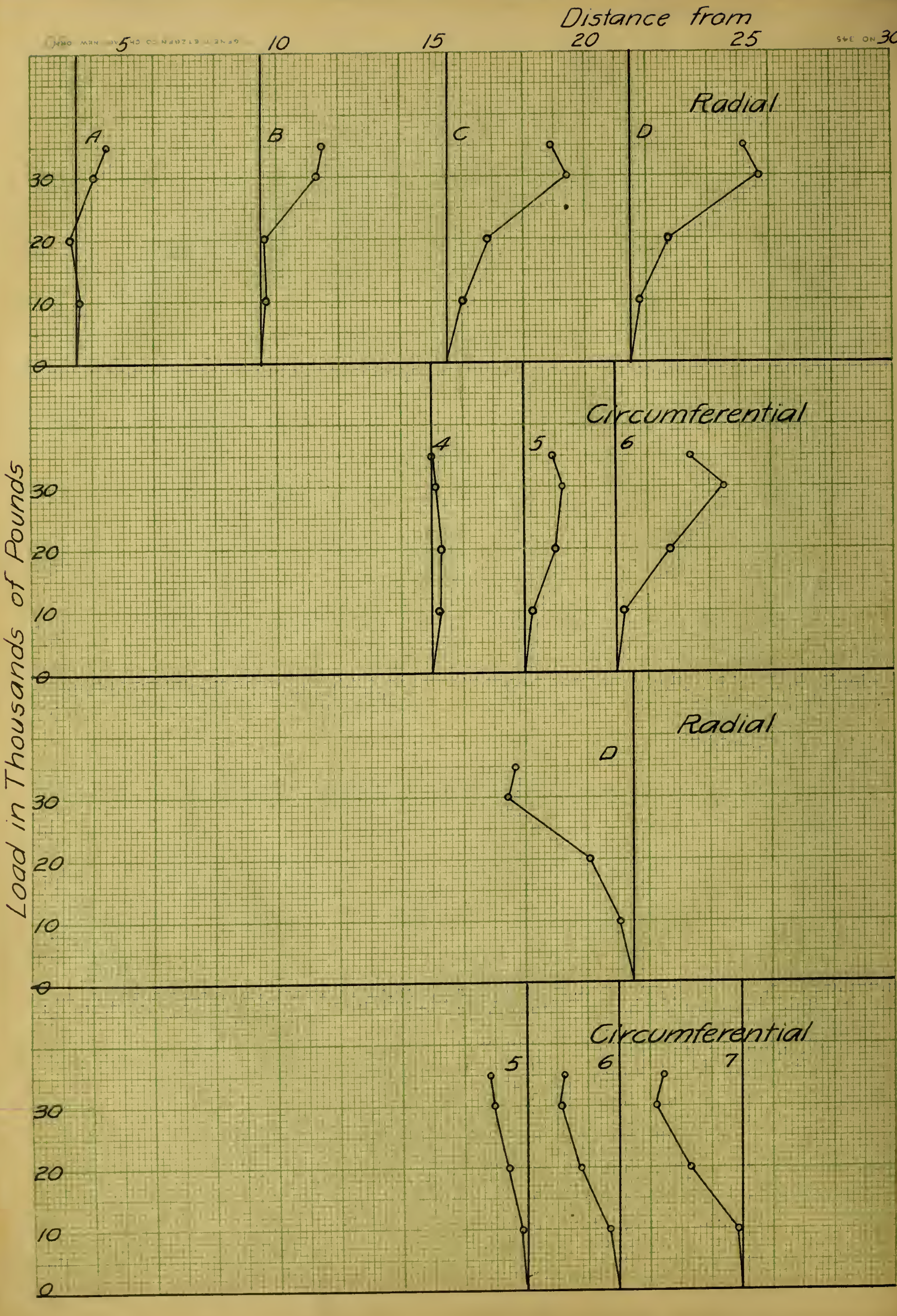
The phenomena of the test of slab 1242 were very similar to those for slab 1241 except that no cracks could be found at a load of 15 000 lb. The same sort of formation of cracks was found as before. This slab ruptured at a load of 33 000 lb. in the same manner as described for slab 1241. Fig 25 shows the

location of cracks and Fig. 24 a view of the ruptured specimen.

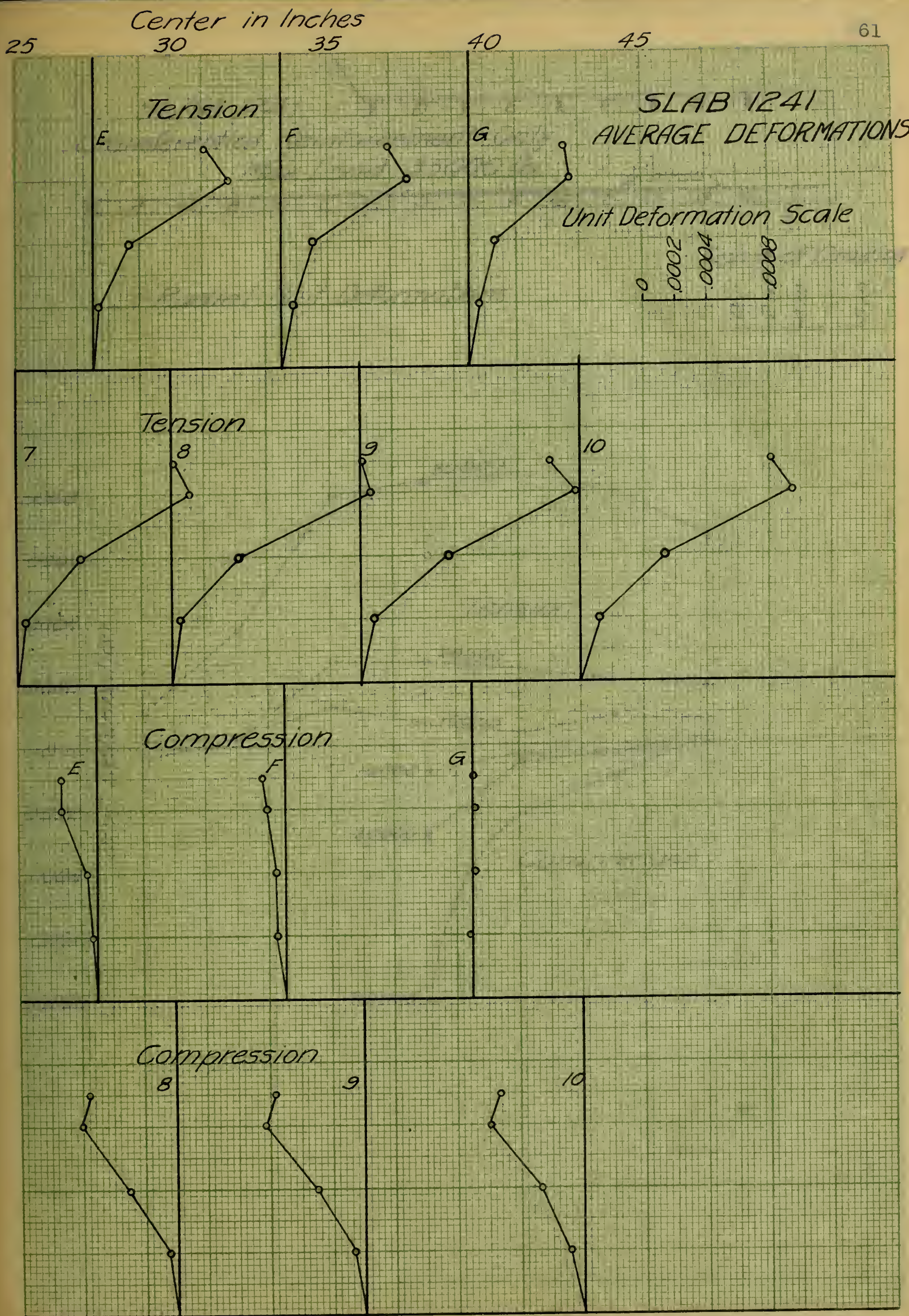
14. <u>Load-deformation</u> <u>Relations.</u>- The load-deformation diagrams for all gage lines on all the slabs have been placed in Part V of this thesis under the heading of Diagrams. A study of the curves for slabs 1241 and 1242 shows a consistency of results of observations on gage lines symmetrical with the center. In the radial direction the unit deformations on the tension side are shown to have increased from the center out to points a little beyond the edge of the column capital where they began to decrease rather slowly. On the compression side the radial deformations decreased very rapidly with the distance from the edge of the column capital, having become practically zero for gage lines G nearest the edge of the slab. Both the tension and compression circumferential deformations increased to points about mid-way between the column capital and the edge of the slab, then decreased slightly along the remaining distance. The diagrams on pages 60, 61, 64, and 65 show the average deformations obtained by averaging the results from gage lines symmetrical with the center, which results checked quite closely. All the curves for slab 1241 show less deformation both radially and circumferentially under a load of 35 000 lb. than for 30 000 lb. The reason for this is the falling off of the load as explained under Phenomena of Tests. On pages 62, 63, 66, and 67 the average deformations are plotted as ordinates with the distances of the gage lines from the center of the slab as abscissas. These diagrams show much more plainly than the others the points of maximum deformations radially and circumferentially and the manner of decrease from these points.



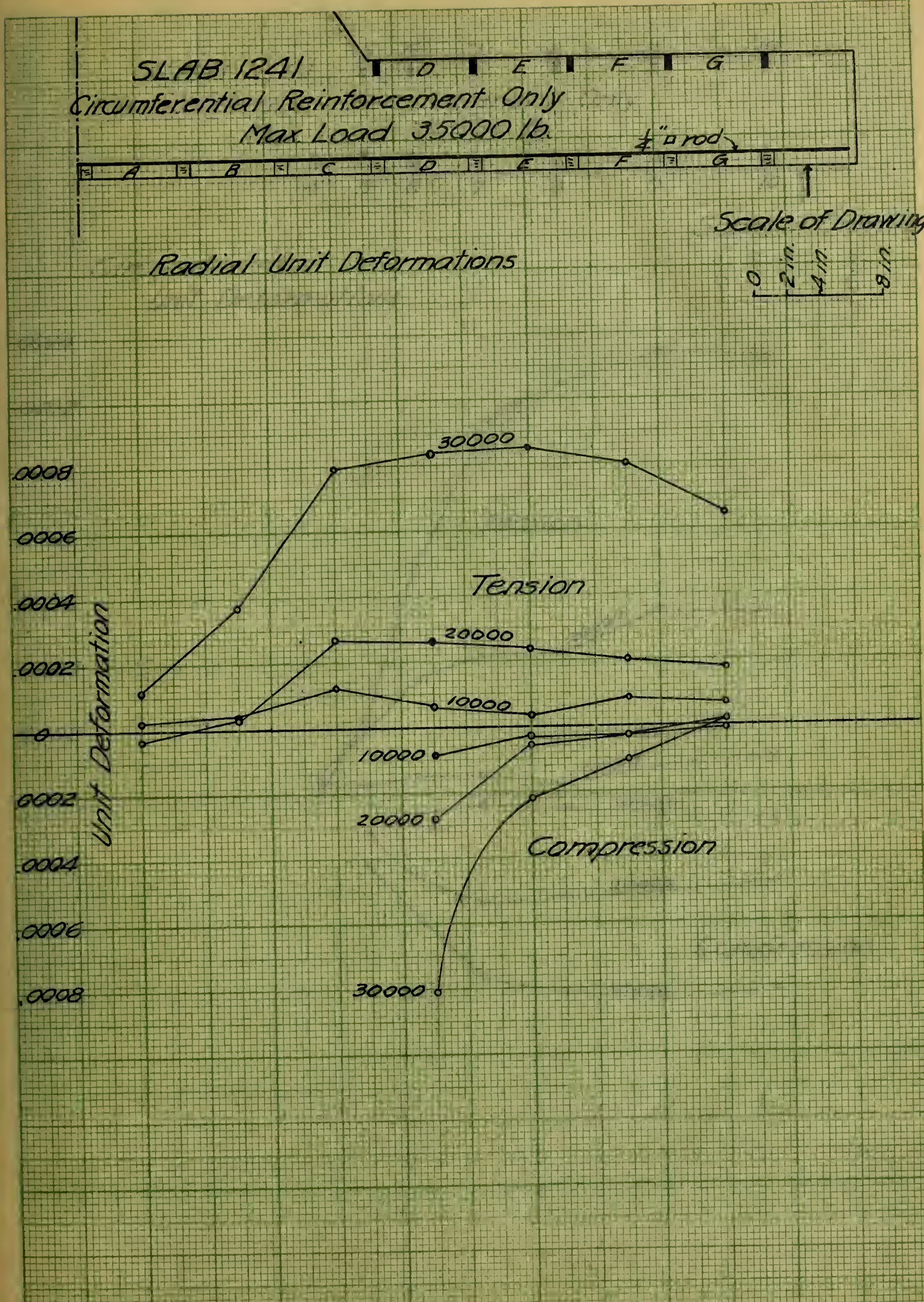
Distance from
Radial
Circumferential
Radial
Circumferential
Load in Thousands of Pounds

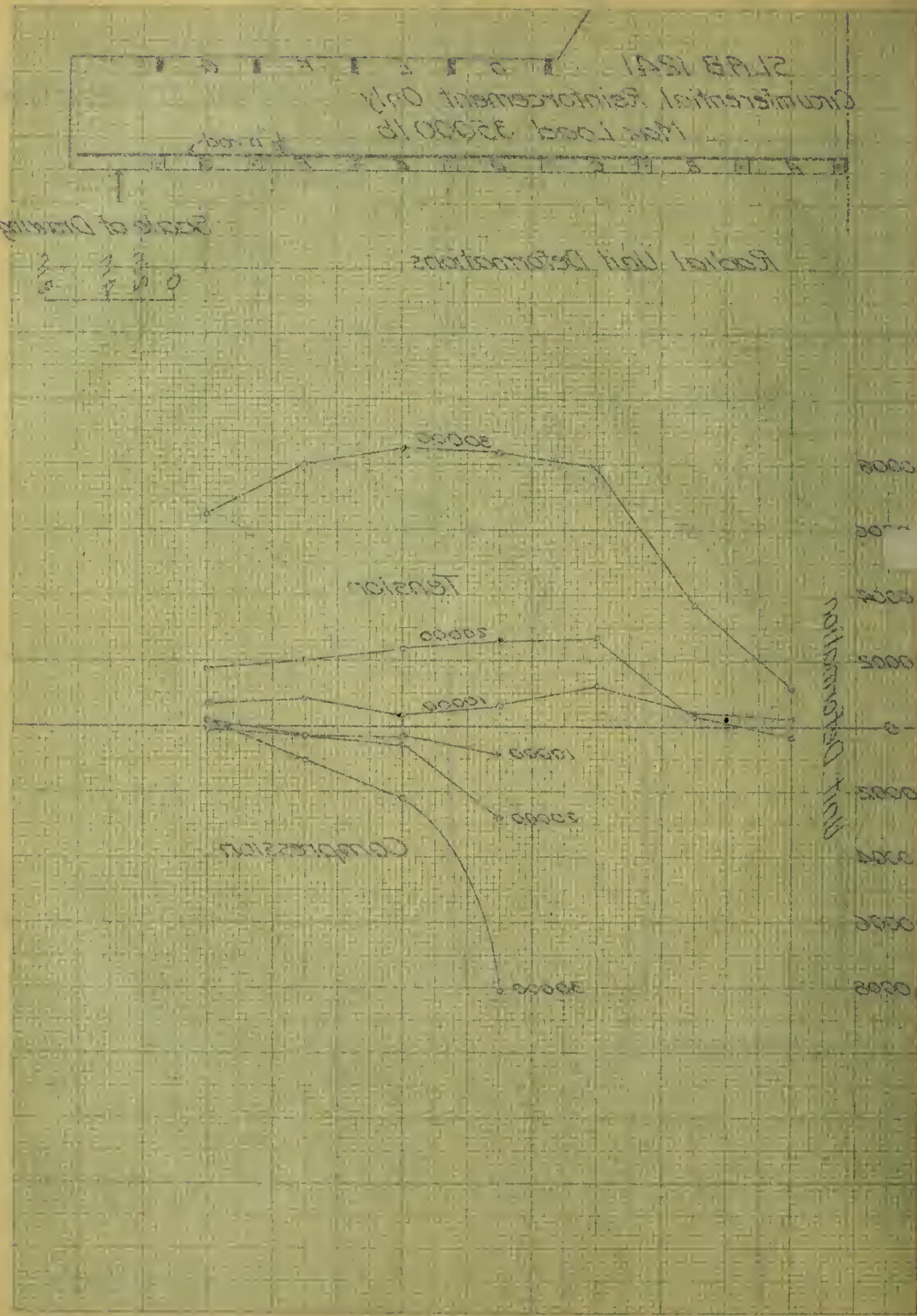


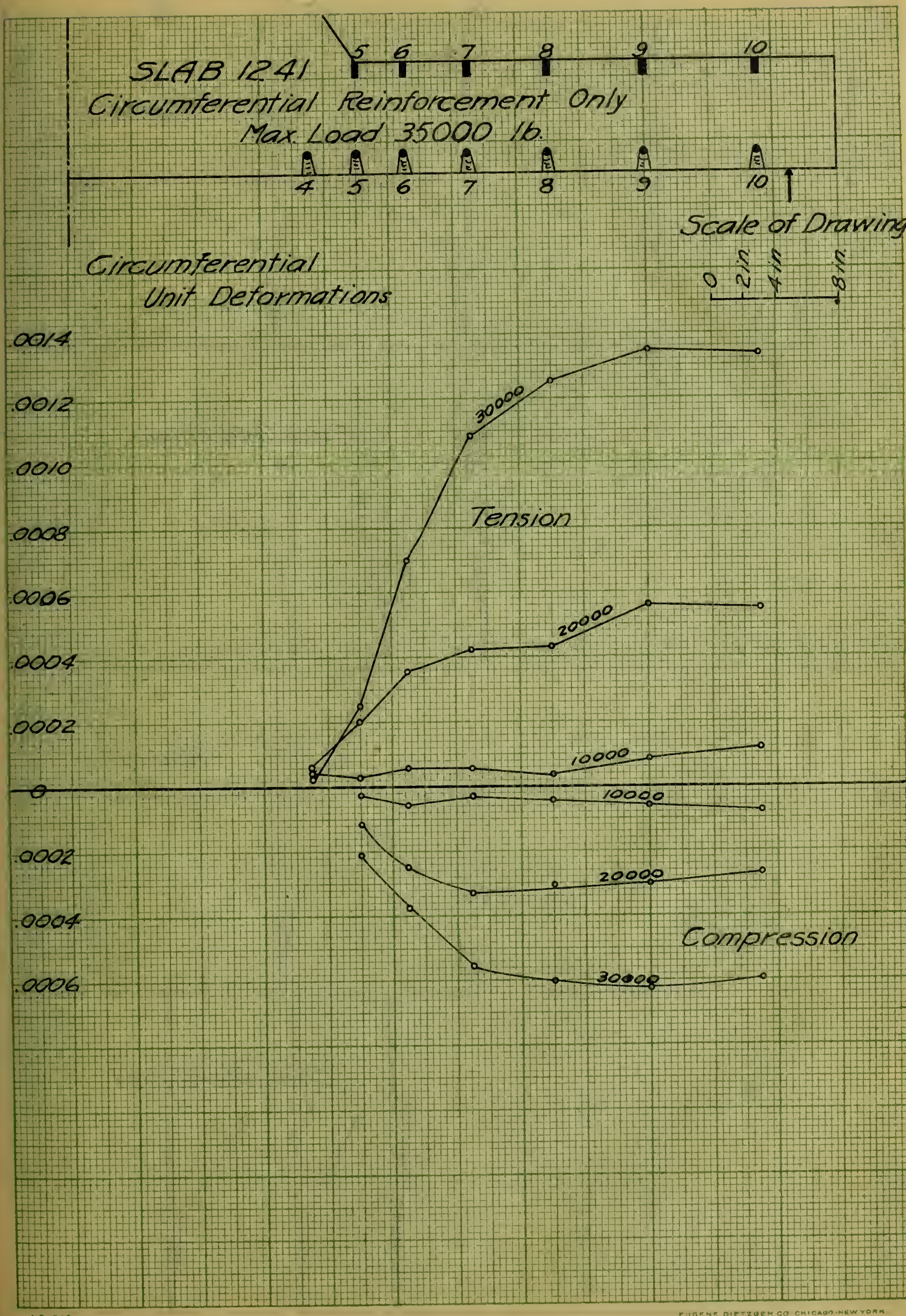
Distance from
5
10
15
20
25
30
Radial
A
B
C
D
Circumferential
4
5
6
Radial
D
Circumferential
5
6
7
Load in Thousands of Pounds
0
10
20
30


Center in Inches
25
30
35
40
45
SLAB 1241
AVERAGE DEFORMATIONS
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E
F
G
Tension
7
8
9
10
Compression
E
F
G
Compression
8
9
10

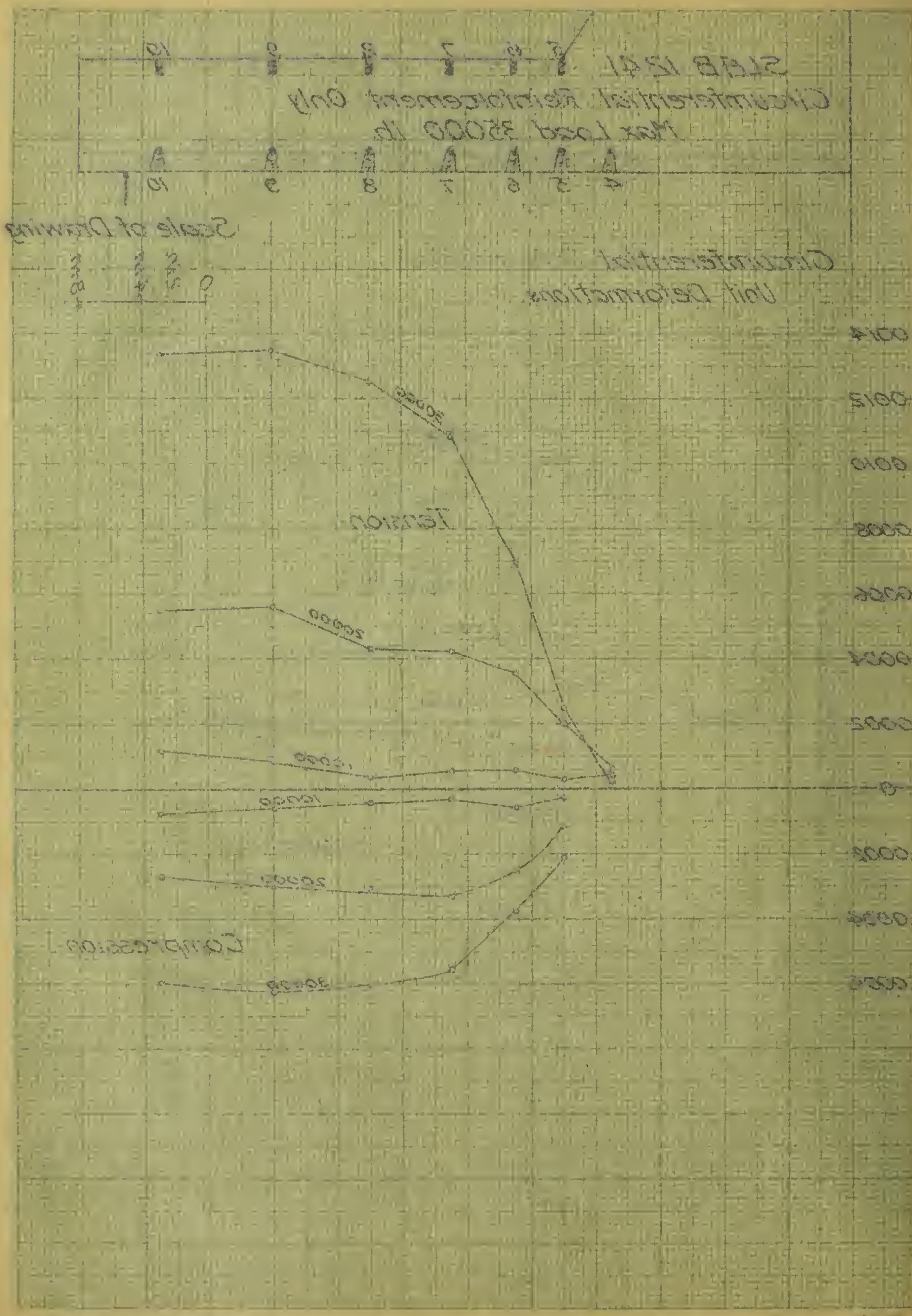

SLAB 1241
AVERAGE DEFORMATIONS
Unit Deformation Scale
Center in inches
25
30
35
40
45
Tension
Tension
Compression
Compression


SLAB 1241
Circumferential Reinforcement Only
Max Load 35000 lb.
$\frac{1}{4}$" ▫ rod
A
B
C
D
E
F
G
Scale of Drawing
0
2 in.
4 in.
8 in.
Radial Unit Deformations
Unit Deformation
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
30000
20000
10000
Tension
10000
20000
30000
Compression

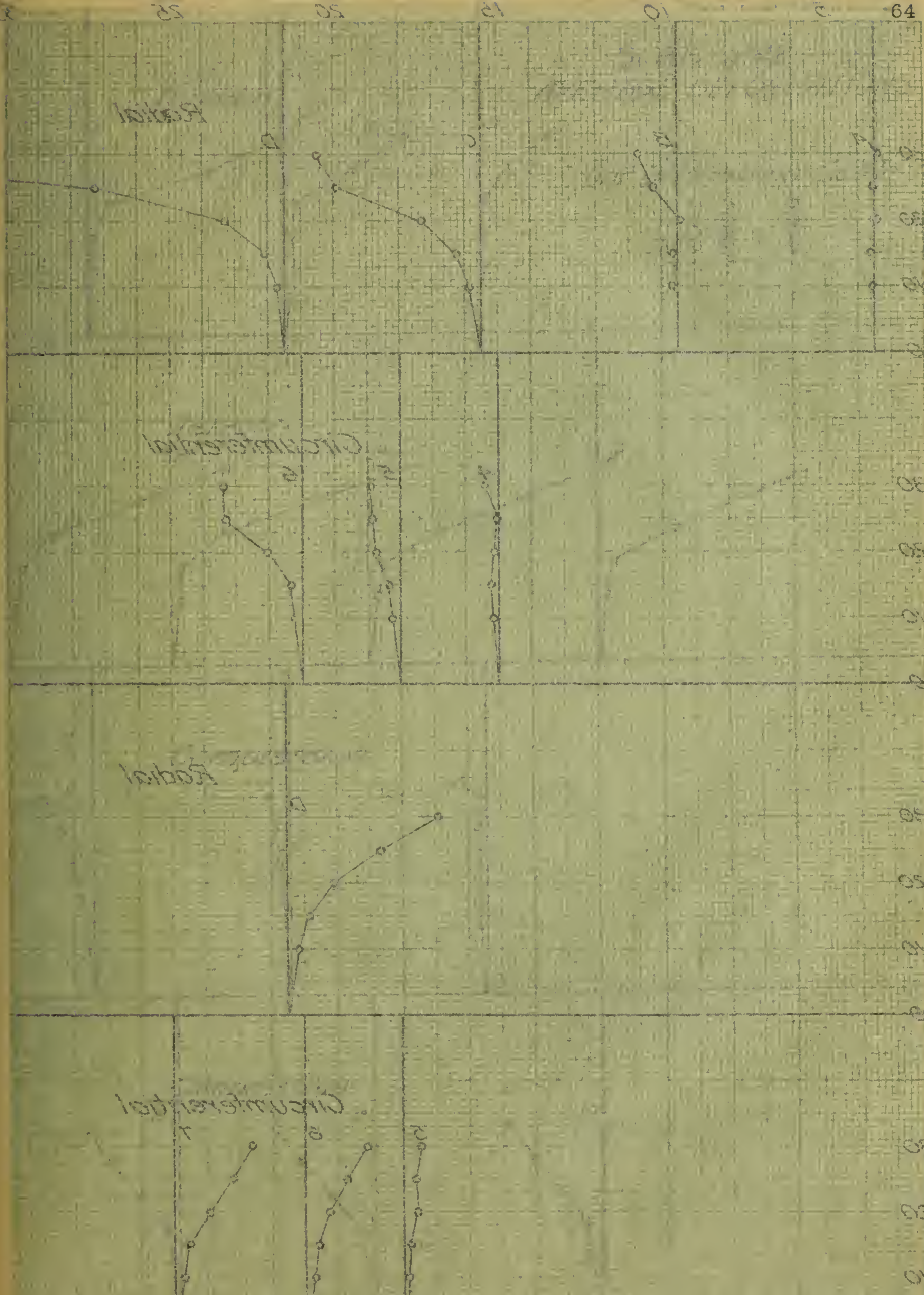

SLAB 12A1
Circumferential Reinforcement Only
Max. Load 35000 lb
Scale of Drawing
Radial Unit Deformations
Tension
Compression
Unit Deformation
30000
20000
10000
10000
20000
30000
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008

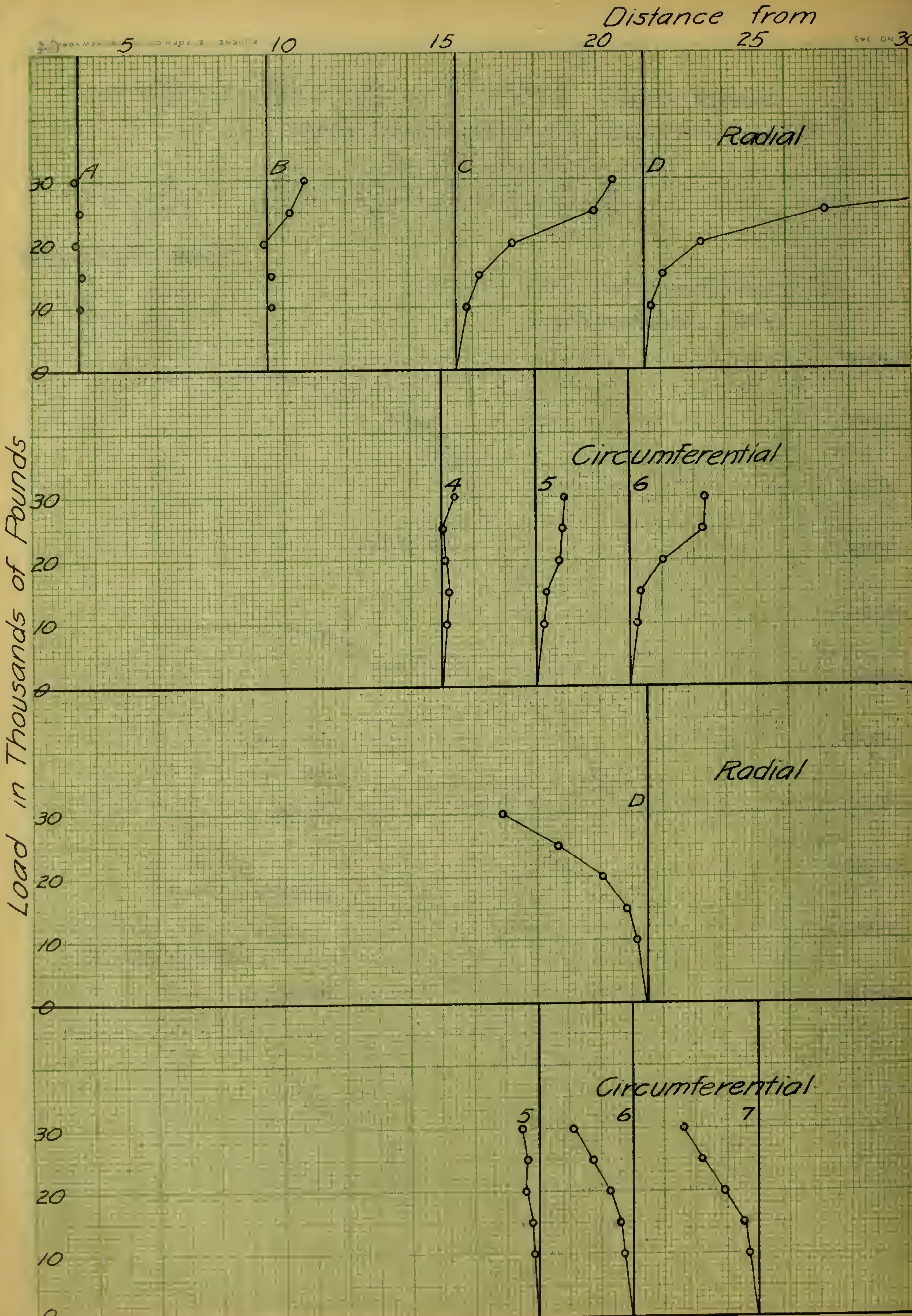


SLAB 1241
Circumferential Reinforcement Only
Max. Load 35000 lb.
5 6 7 8 9 10
4 5 6 7 8 9 10
Scale of Drawing
0 2 in. 4 in. 8 in.
Circumferential
Unit Deformations
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
30000
Tension
20000
10000
10000
20000
Compression
30000
NO. 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK

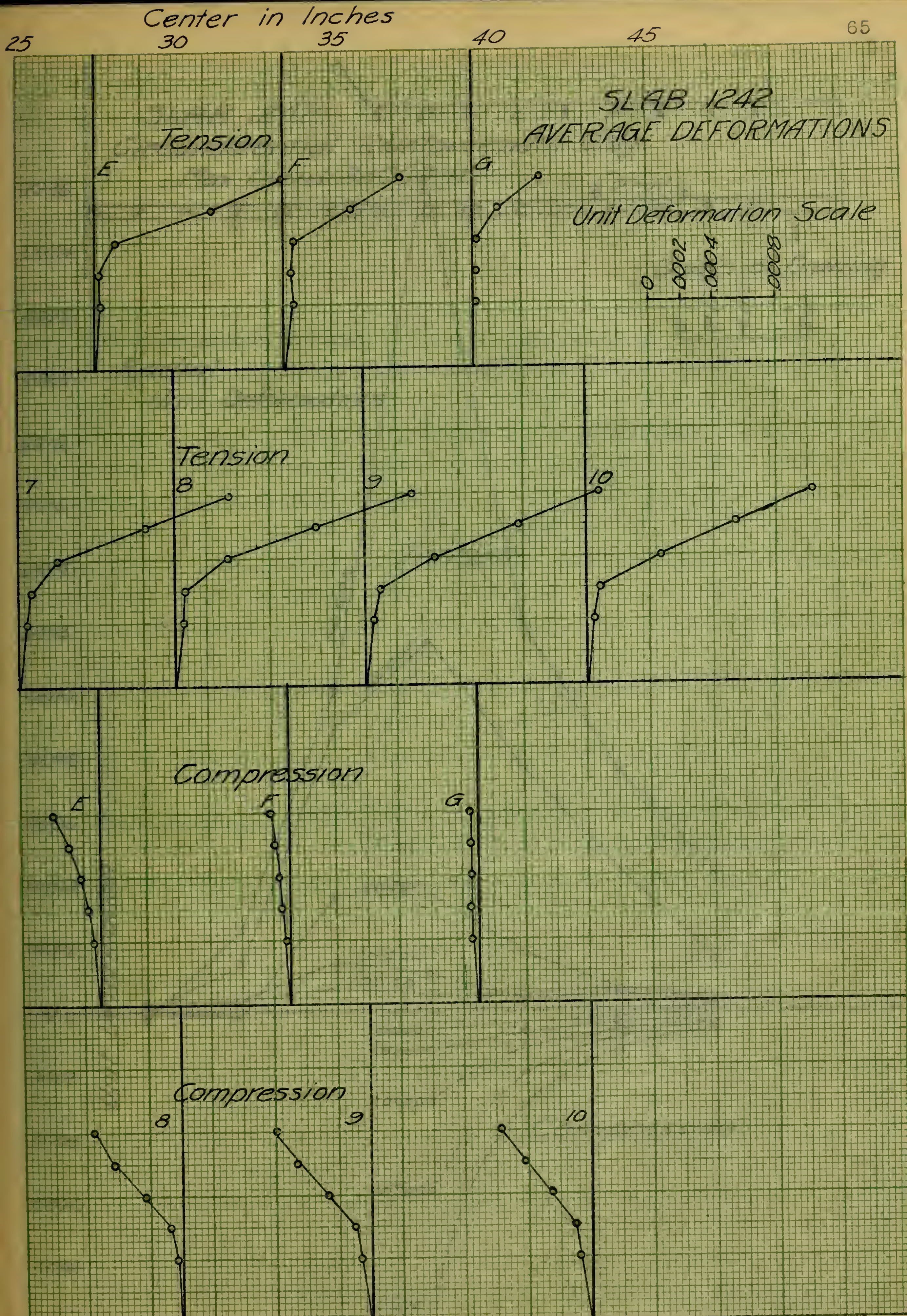


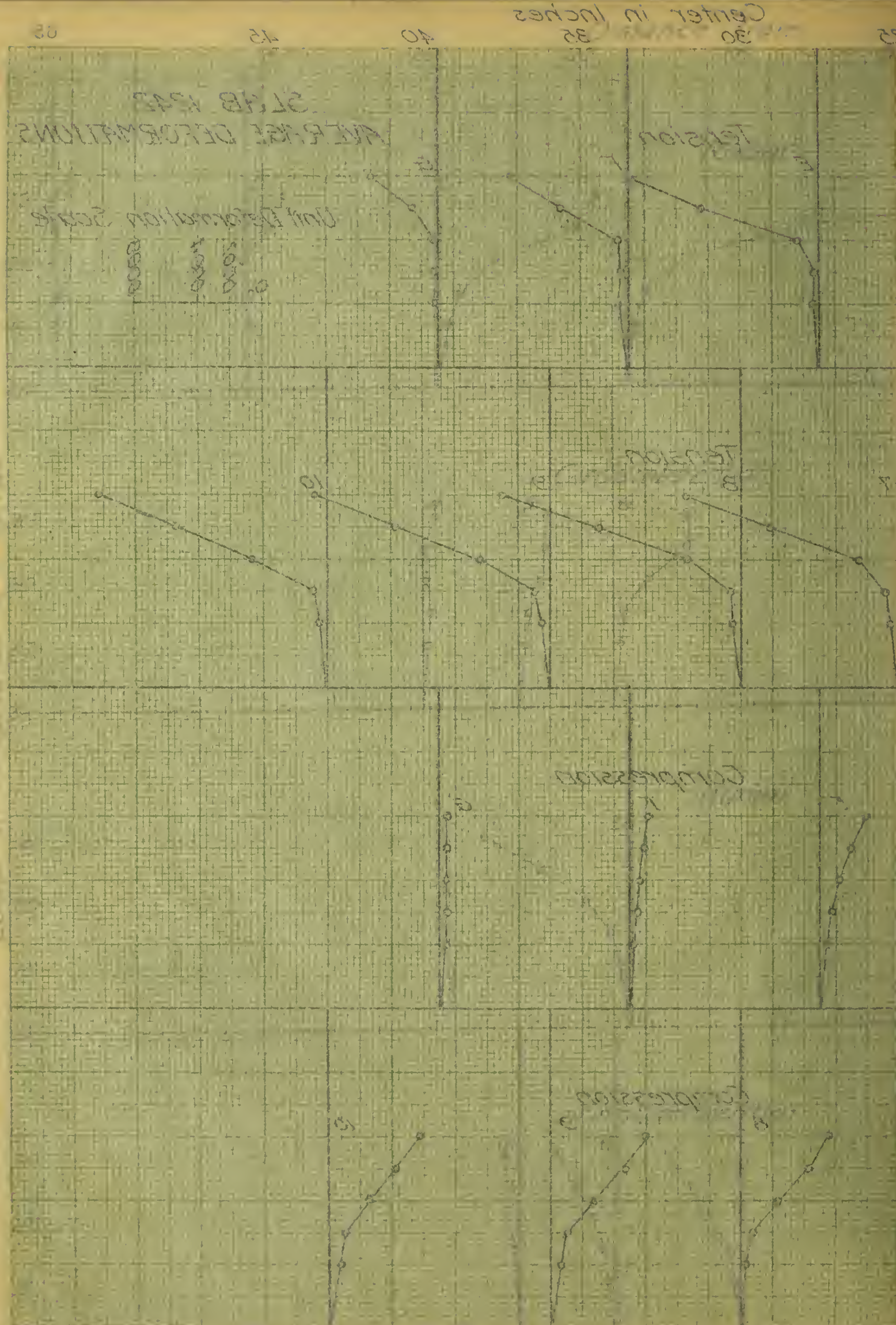
SLAB 1241
Circumferential Reinforcement Only
Max Load 35000 lb.
Scale of Drawing
Circumferential
Unit Deformations
Tension
Compression
30000
20000
10000
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006


Distance from
Radial
Circumferential
Radial
Circumferential
Load in Thousands of Pounds

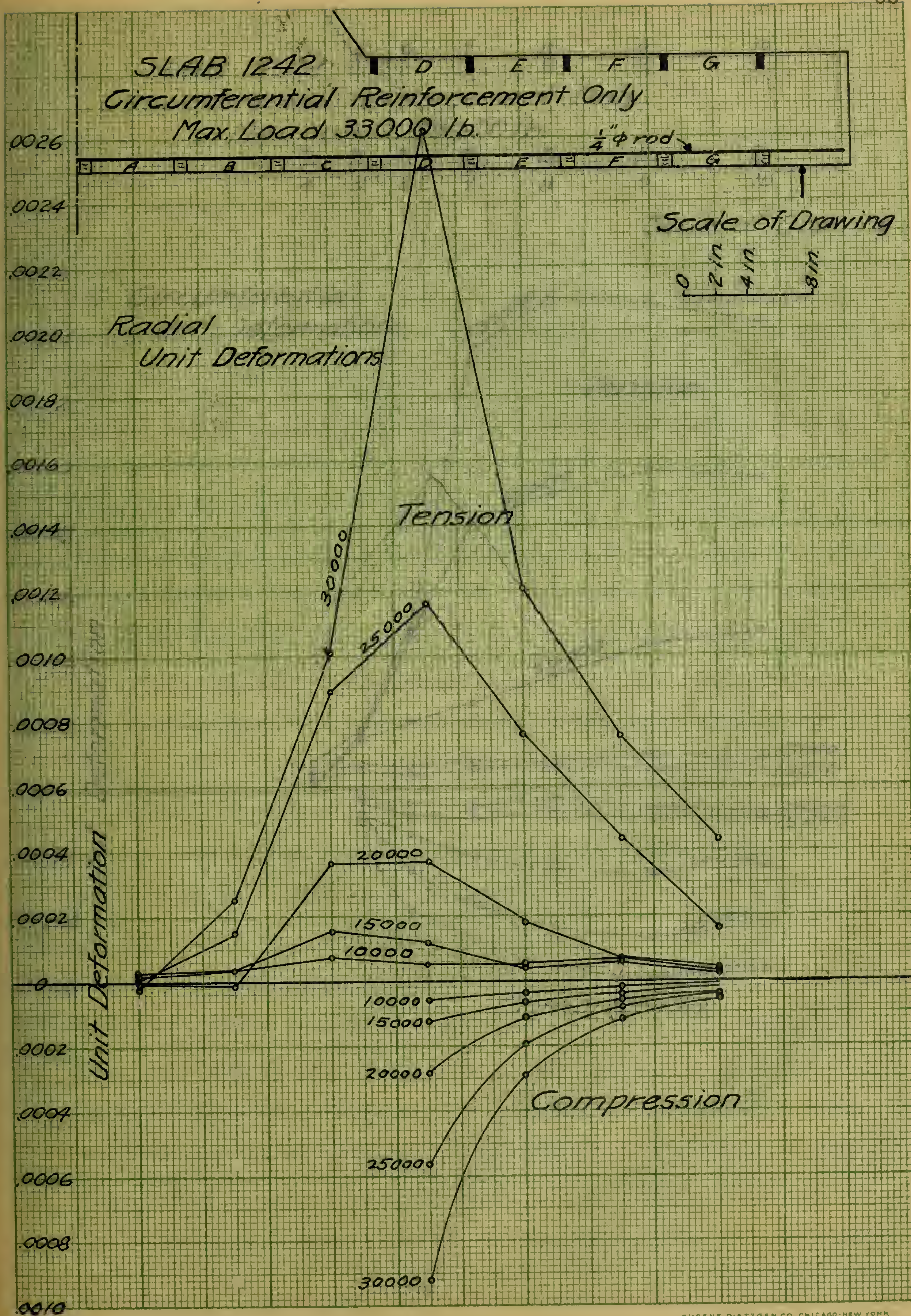


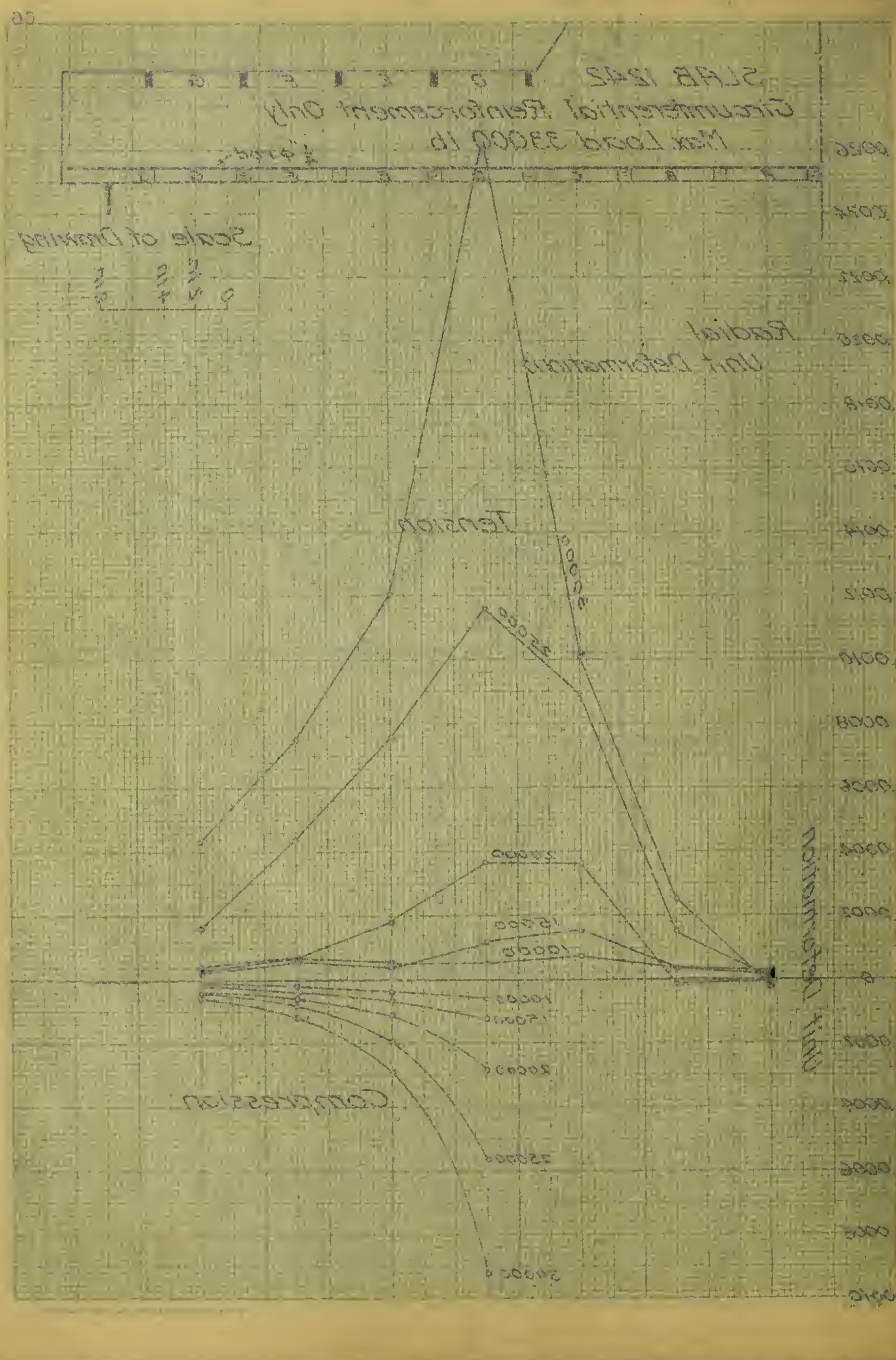
Distance from
5
10
15
20
25
30
Load in Thousands of Pounds
Radial
A
B
C
D
30
20
10
0
Circumferential
4
5
6
Radial
D
Circumferential
5
6
7


Center in Inches
25
30
35
40
45
SLAB 1242
AVERAGE DEFORMATIONS
Tension
E
F
G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
7
8
9
10
Compression
E
F
G
Compression
8
9
10

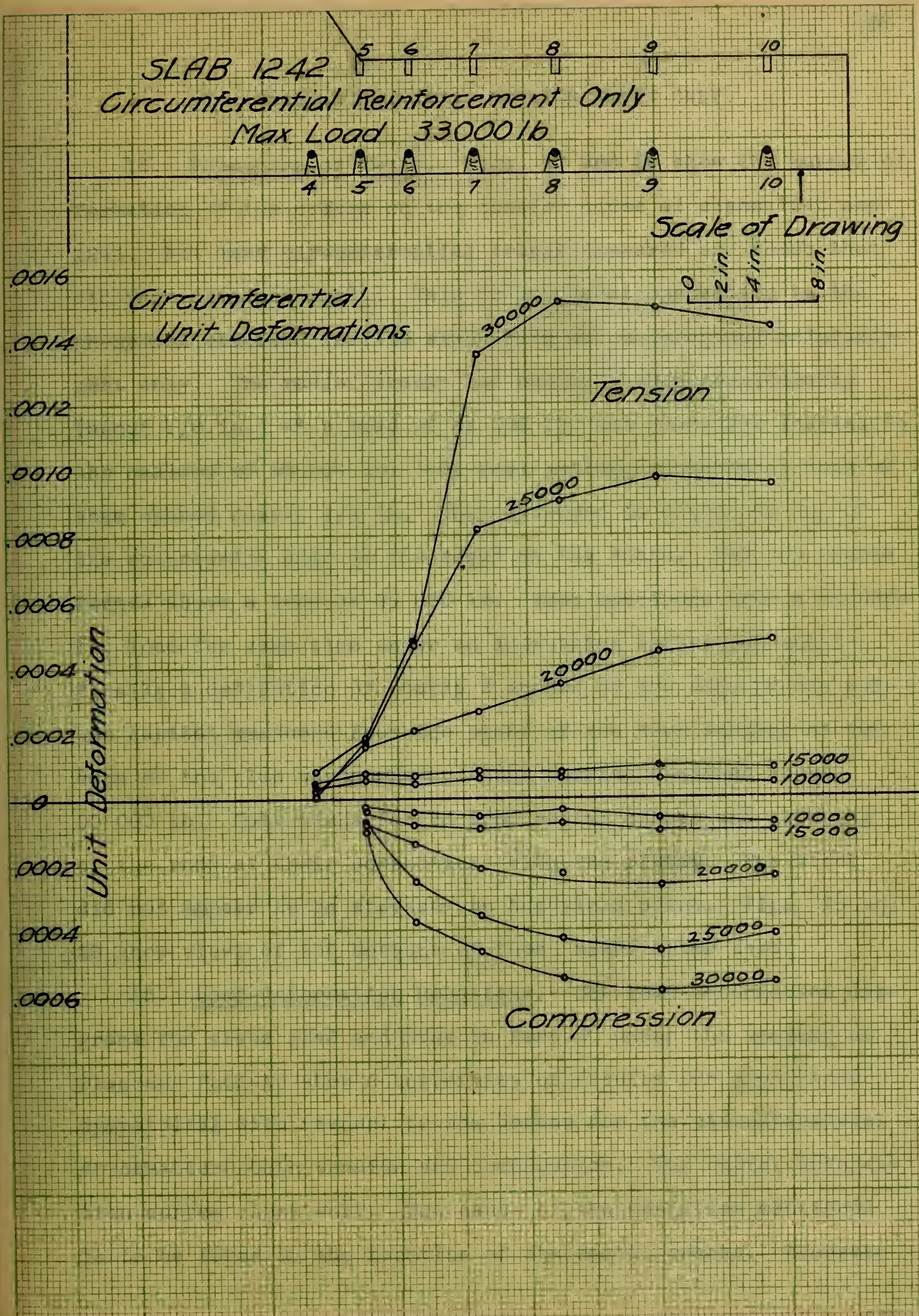


Center in Inches
25
30
35
40
45
50
Average Deformations
Unit Deformation Scale
Tension
Compression

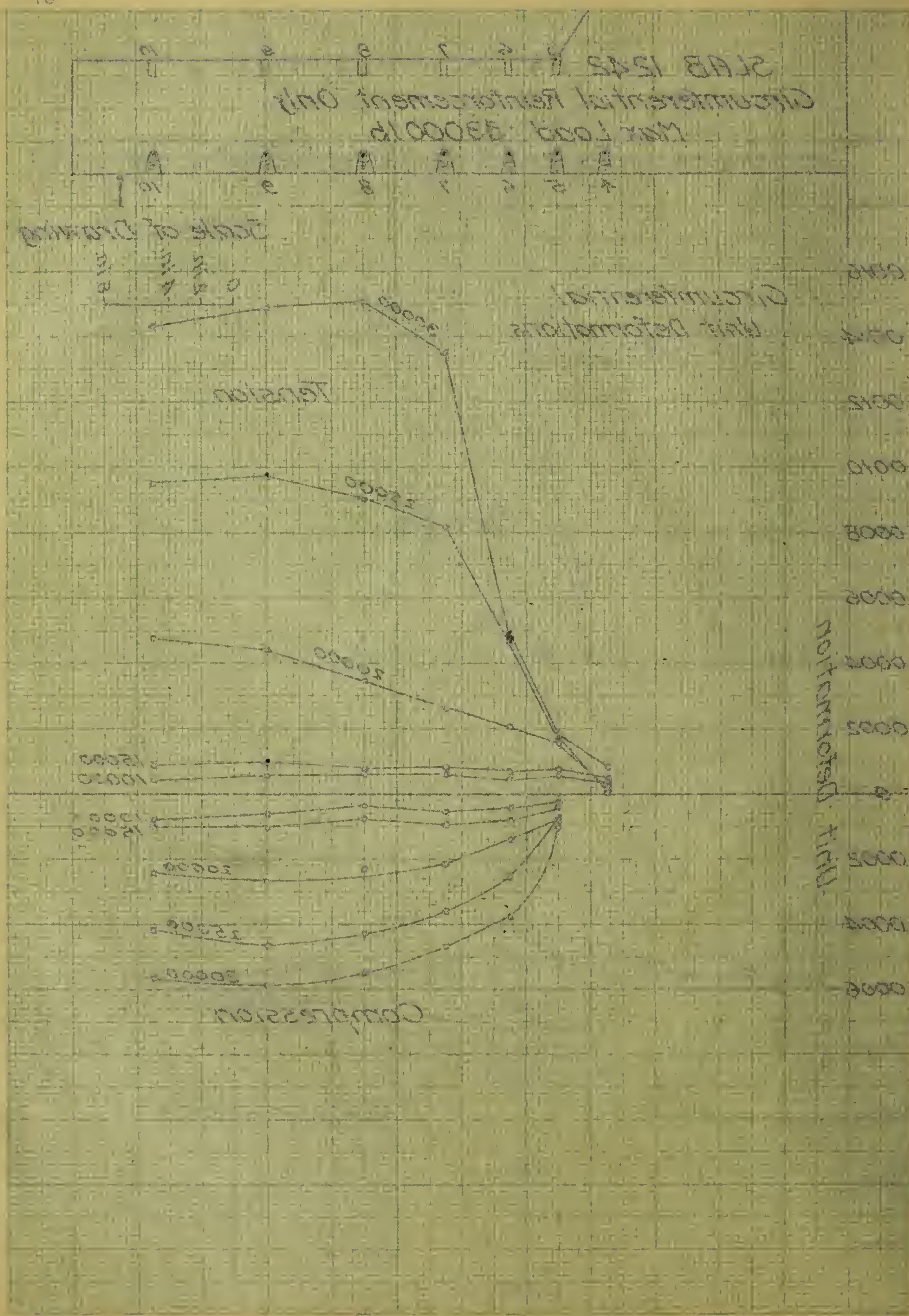

SLAB 1242
Circumferential Reinforcement Only
Max. Load 33000 lb.
A
B
C
D
E
F
G
1/4" φ rod
Scale of Drawing
0
2 in.
4 in.
8 in.
Radial
Unit Deformations
Tension
Compression
Unit Deformation
.0026
.0024
.0022
.0020
.0018
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
30000
25000
20000
15000
10000
10000
15000
20000
25000
30000
RD 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK



SLAB 1242
Circumferential Reinforcement Only
Max Load 33000 lb
Scale of Drawing
Radial
Unit Deformation
Tension
Compression
Unit Deformation



SLAB 1242
Circumferential Reinforcement Only
Max Load 33000 lb
5 6 7 8 9 10
4 5 6 7 8 9 10
Scale of Drawing
0 2 in. 4 in. 8 in.
Circumferential Unit Deformations
Tension
Compression
Unit Deformation
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
30000
25000
20000
15000
10000
10000
15000
20000
25000
30000


SLAB 1242
Circumferential Reinforcement Only
Max Load 33000 lb
Scale of Drawing
Circumferential
Unit Deformations
Tension
Compression
Unit Deformation
30000
25000
20000
15000
10000
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006

B. SLABS WITH RADIAL REINFORCEMENT ONLY.

15. Phenomena of Tests.- Figs. 27 and 29 show the manner of formation of the cracks on the tension sides of slabs 1243 and 1244. Not many circumferential cracks appeared and those that did form remained small. This is in direct opposition to the phenomena observed for the slabs with circumferential reinforcement only. The radial cracks had begun to open considerably (about 1/8 in.) at a load of 35 000 lb. and from this loading to the maximum of 50 000 lb. they kept getting wider until some of them opened nearly 1/4 in. They extended to within $1\frac{1}{2}$ in. of the compression side at the edges of the slabs. Few new cracks formed above a load of 30 000 lb. Both specimens held a 50 000-lb. load for some time under an increasing deflection until finally a deflection of nearly 2 inches at the edge of the column capital measured from the plane of the flat portion at the edge of the slab was reached without forcing the load above 50 000 lb. Both slabs failed from radial cracks and slipping of the rods at their connections with the plates. The steel did not appear to be stressed to the yield point. Figs. 26 and 28 show views of the bottoms of these slabs after test.

16. Load-deformation Relations.- The load-deformation diagrams for slabs 1243 and 1244 in Part V under the heading of Diagrams fail to show a uniformity of results for gage lines symmetrical with respect to the center for the circumferential deformations both tension and compression. The radial deformation curves check well. The cause of the variation mentioned is to be found in the location of the radial cracks. Wherever

Fig.26. Slab 1243.-View Showing Manner of Failure.

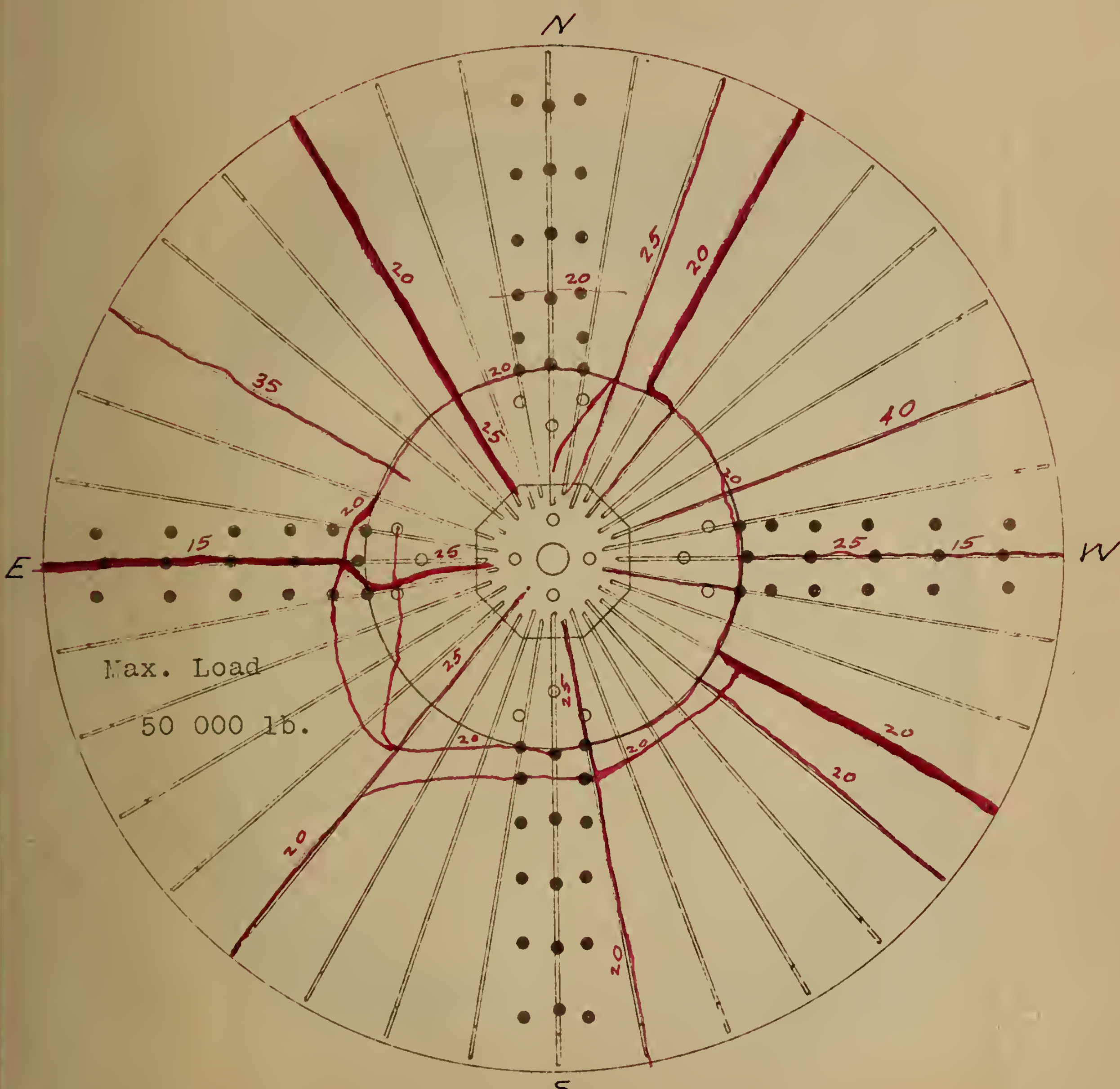


Fig.27. Slab 1243.-Location of Cracks.

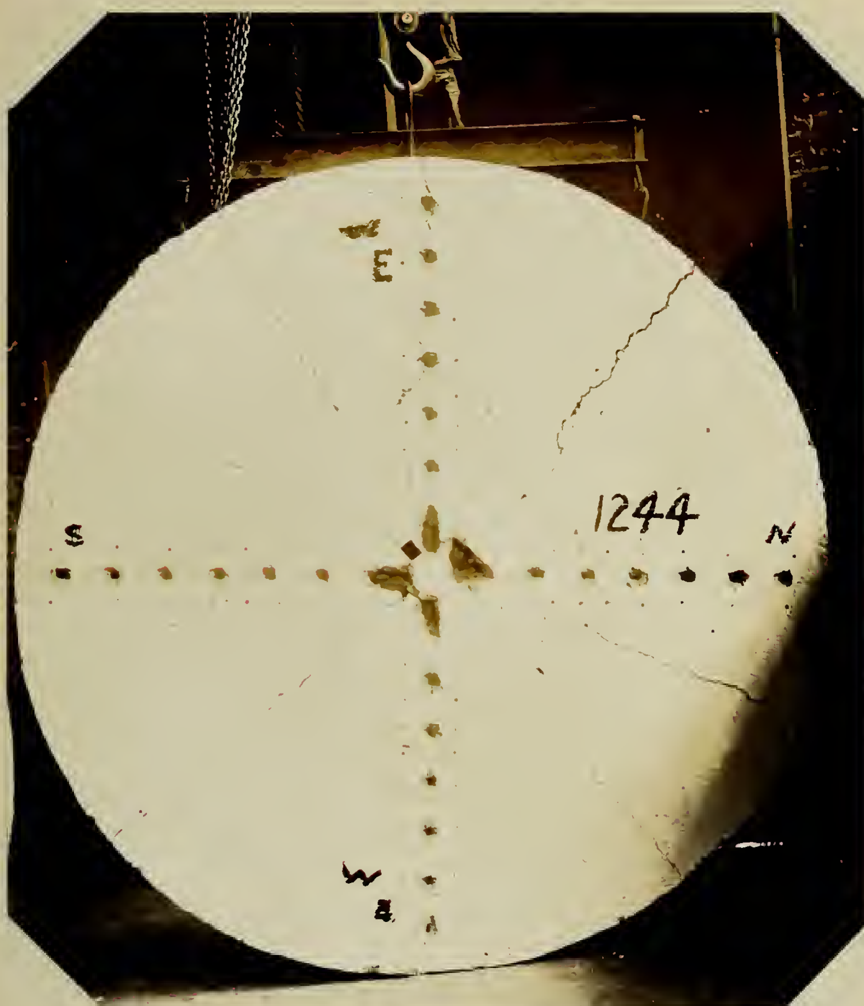


Fig.28. Slab 1244.-View Showing Manner of Failure.

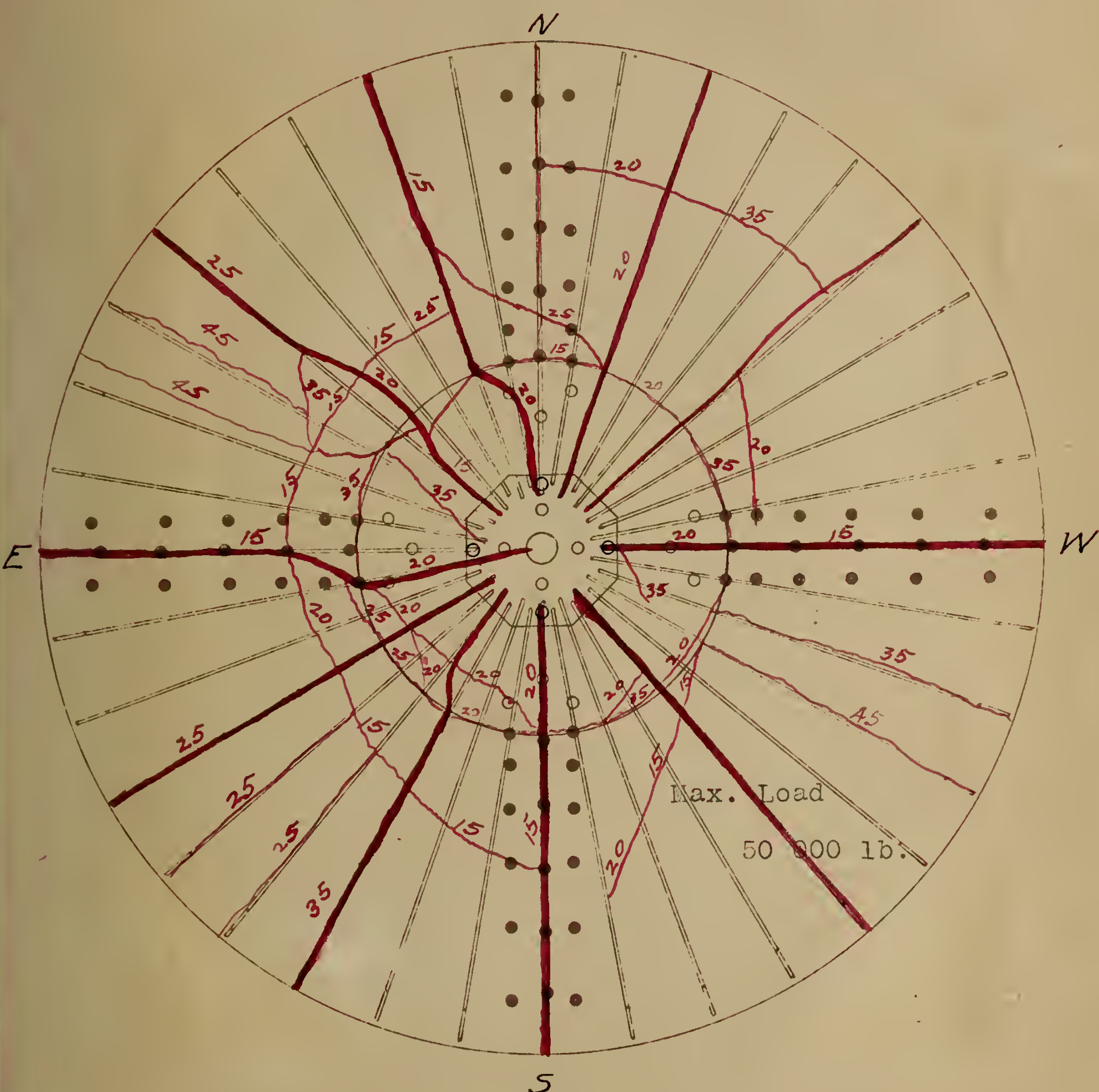
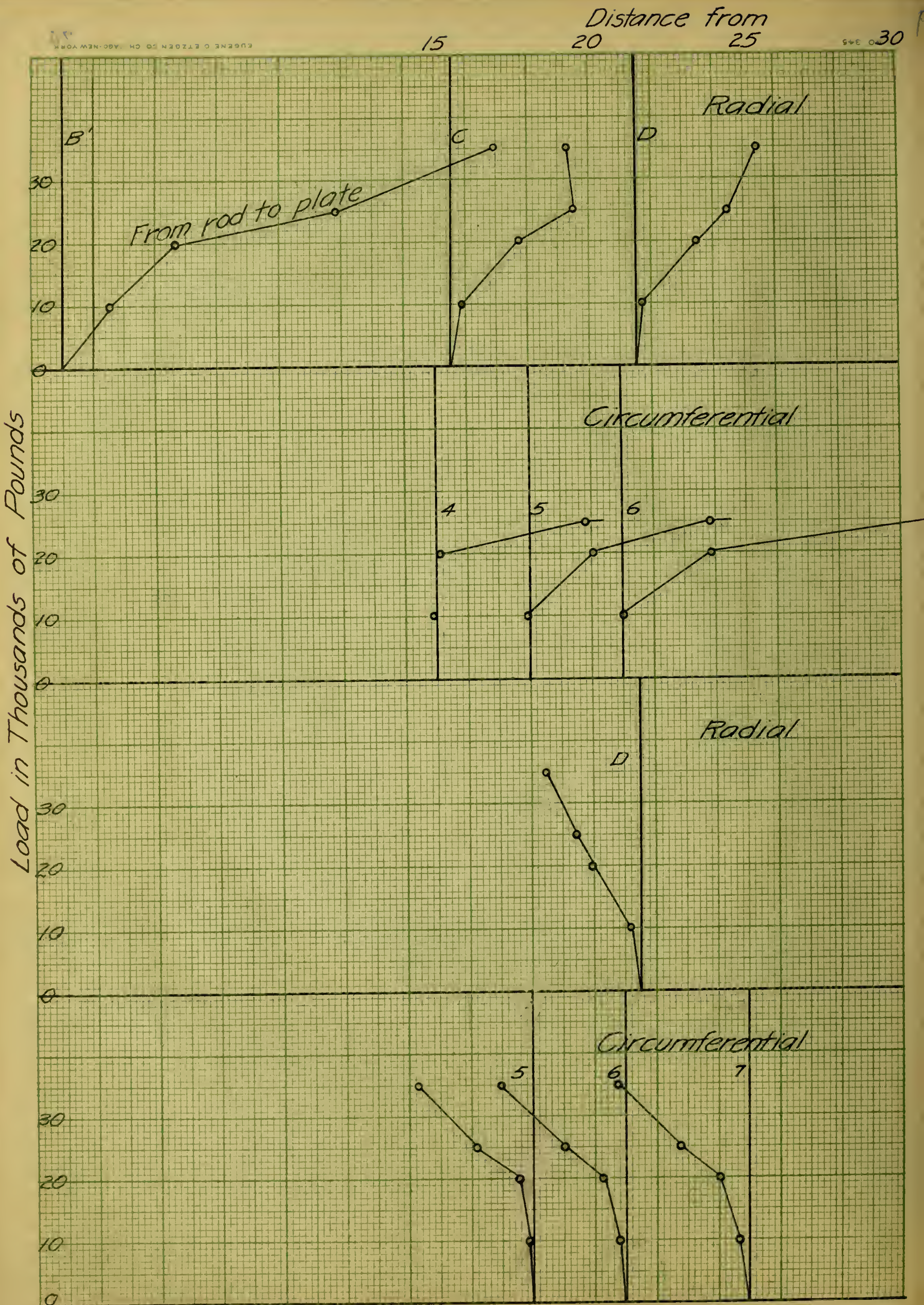
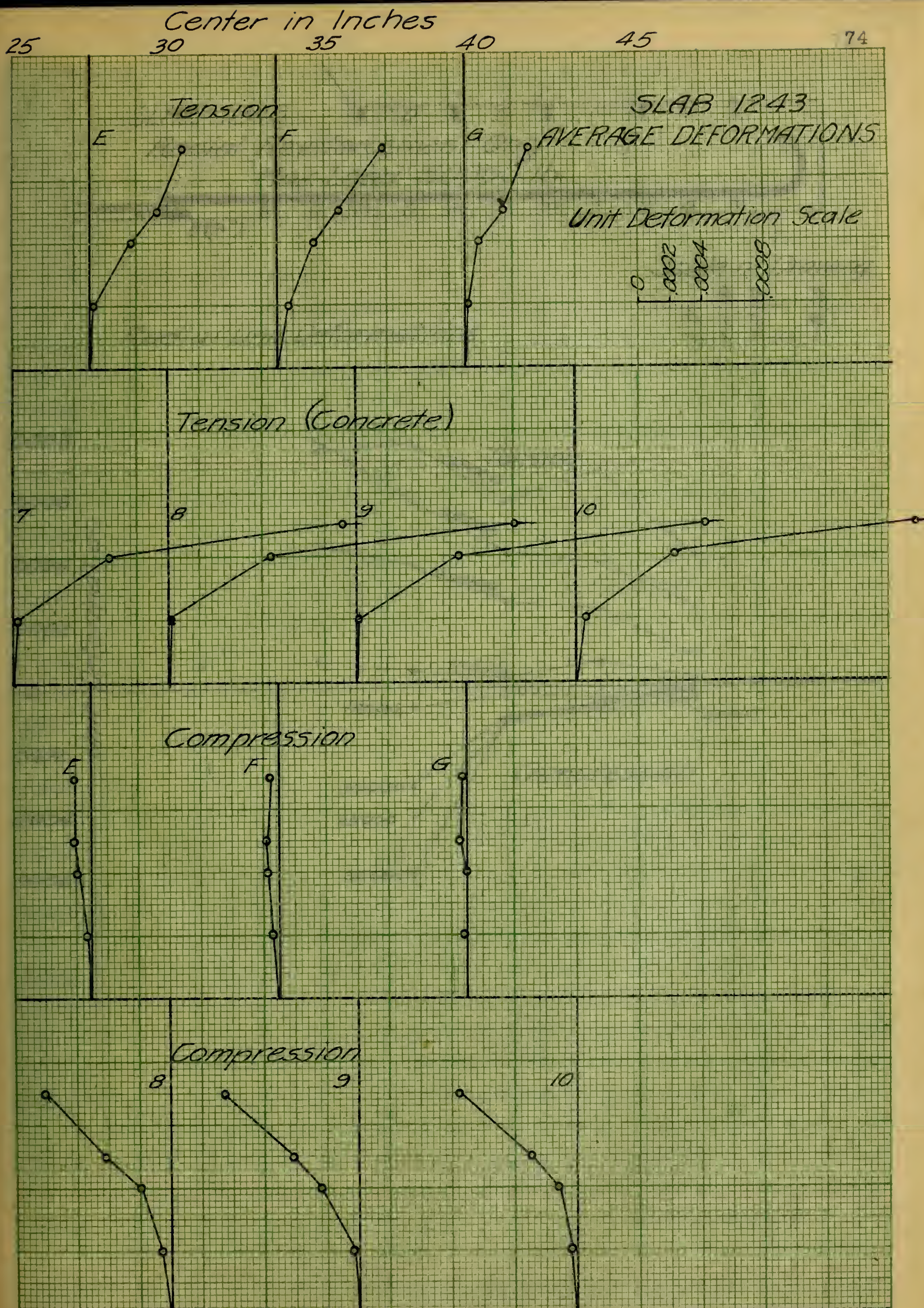
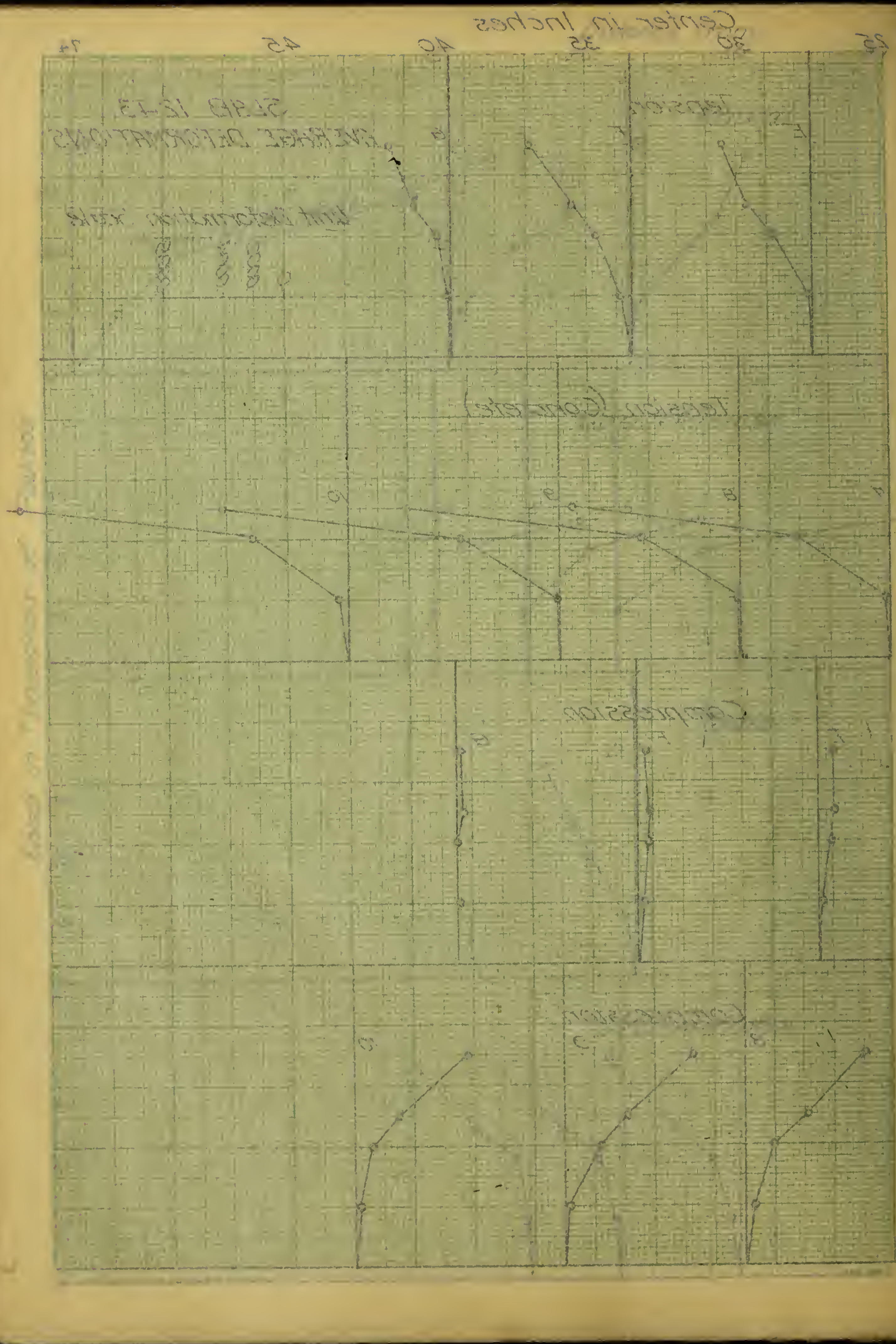


Fig. 29. Slab 1244.-Location of Cracks.

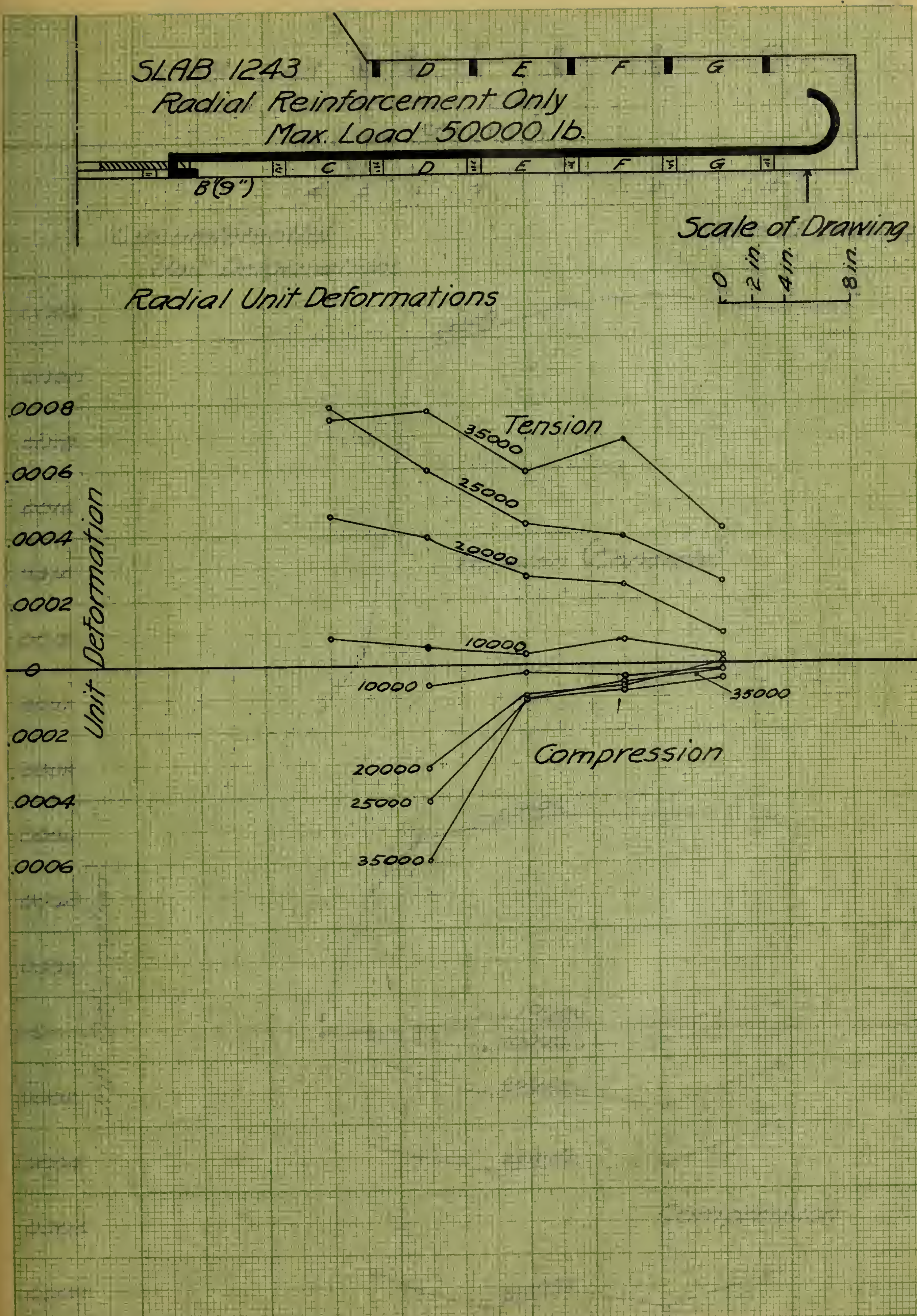


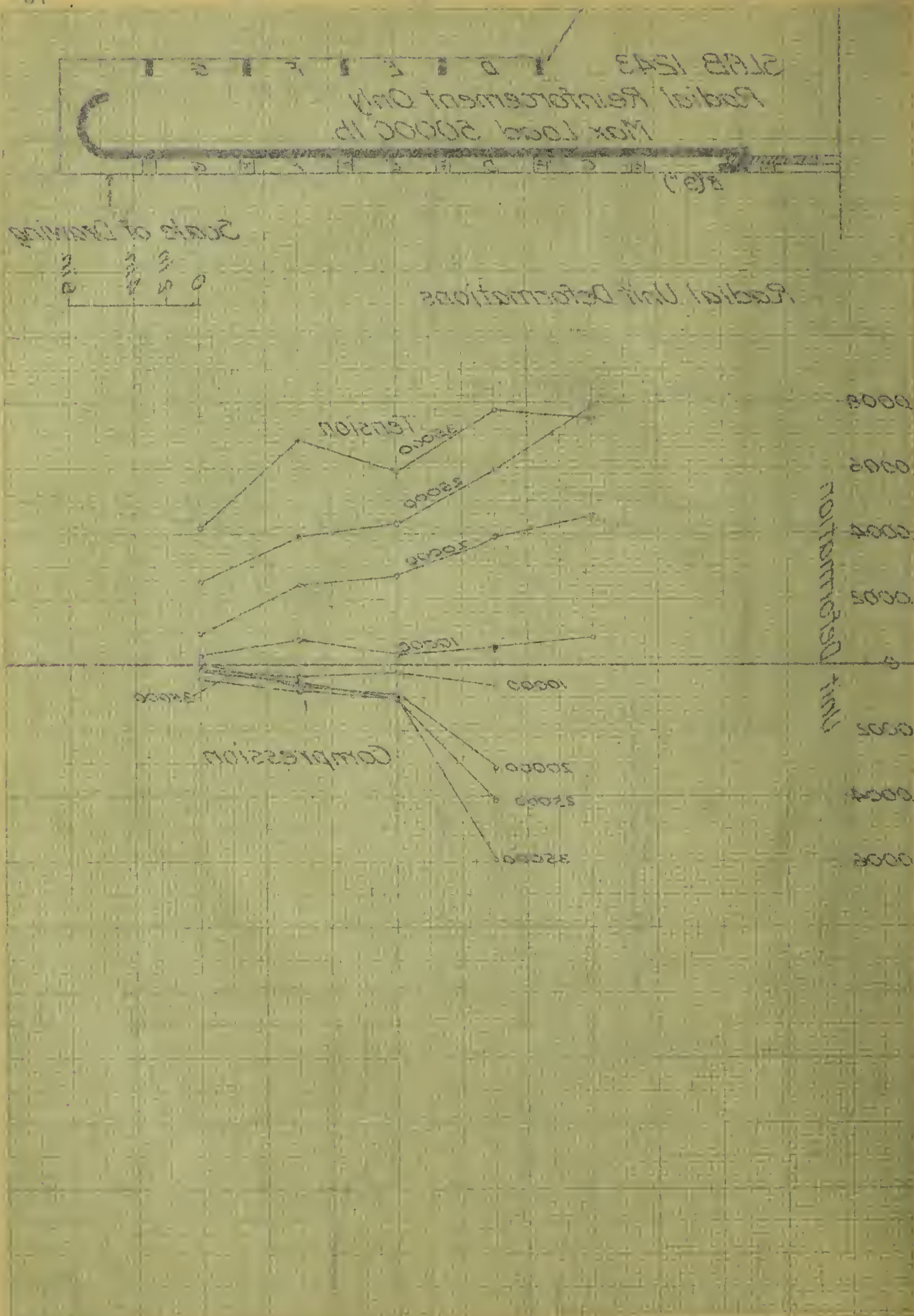
Distance from
15
20
25
30
Radial
B'
C
D
From rod to plate
30
20
10
0
Circumferential
4
5
6
Load in Thousands of Pounds
Radial
D
Circumferential
5
6
7

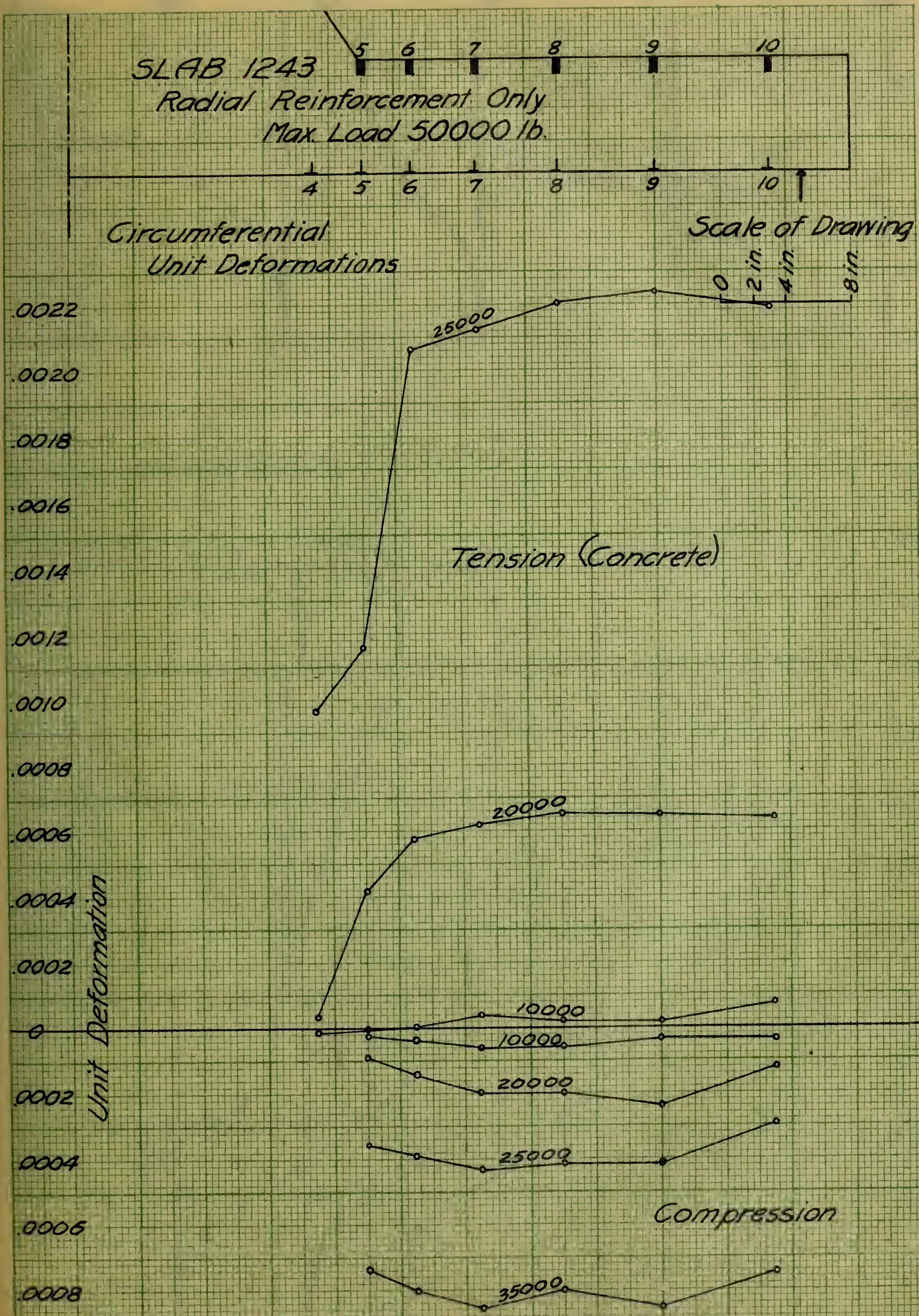

Center in Inches
25
30
35
40
45
SLAB 1243
AVERAGE DEFORMATIONS
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E
F
G
Tension (Concrete)
7
8
9
10
Compression
E
F
G
Compression
8
9
10



Center in Inches
SLAB 12-13
AVERAGE DEFORMATIONS
Unit Deformation Scale
Tension
Tension (Concrete)
Compression

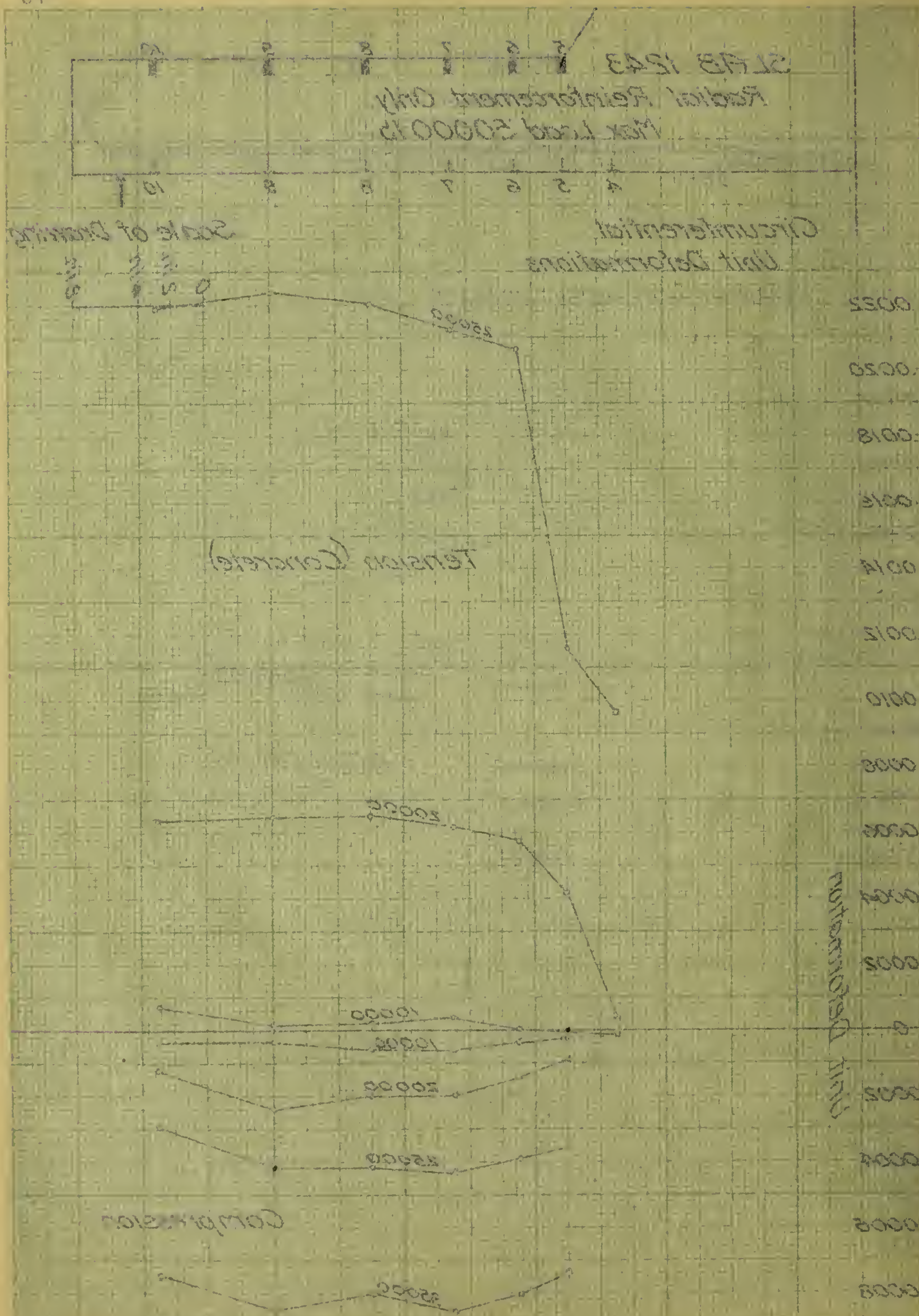

SLAB 1243
Radial Reinforcement Only
Max. Load 50000 lb.
B(9")
C
D
E
F
G
Scale of Drawing
0
2 in.
4 in.
8 in.
Radial Unit Deformations
Unit Deformation
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
Tension
35000
25000
20000
10000
Compression
10000
20000
25000
35000
35000


Slab 1243
Radial Reinforcement Only
Max Load 50000 lb.
Scale of Drawing
Radial Unit Deformations
Tension
Compression
Unit Deformation
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
30000
25000
20000
10000
35000

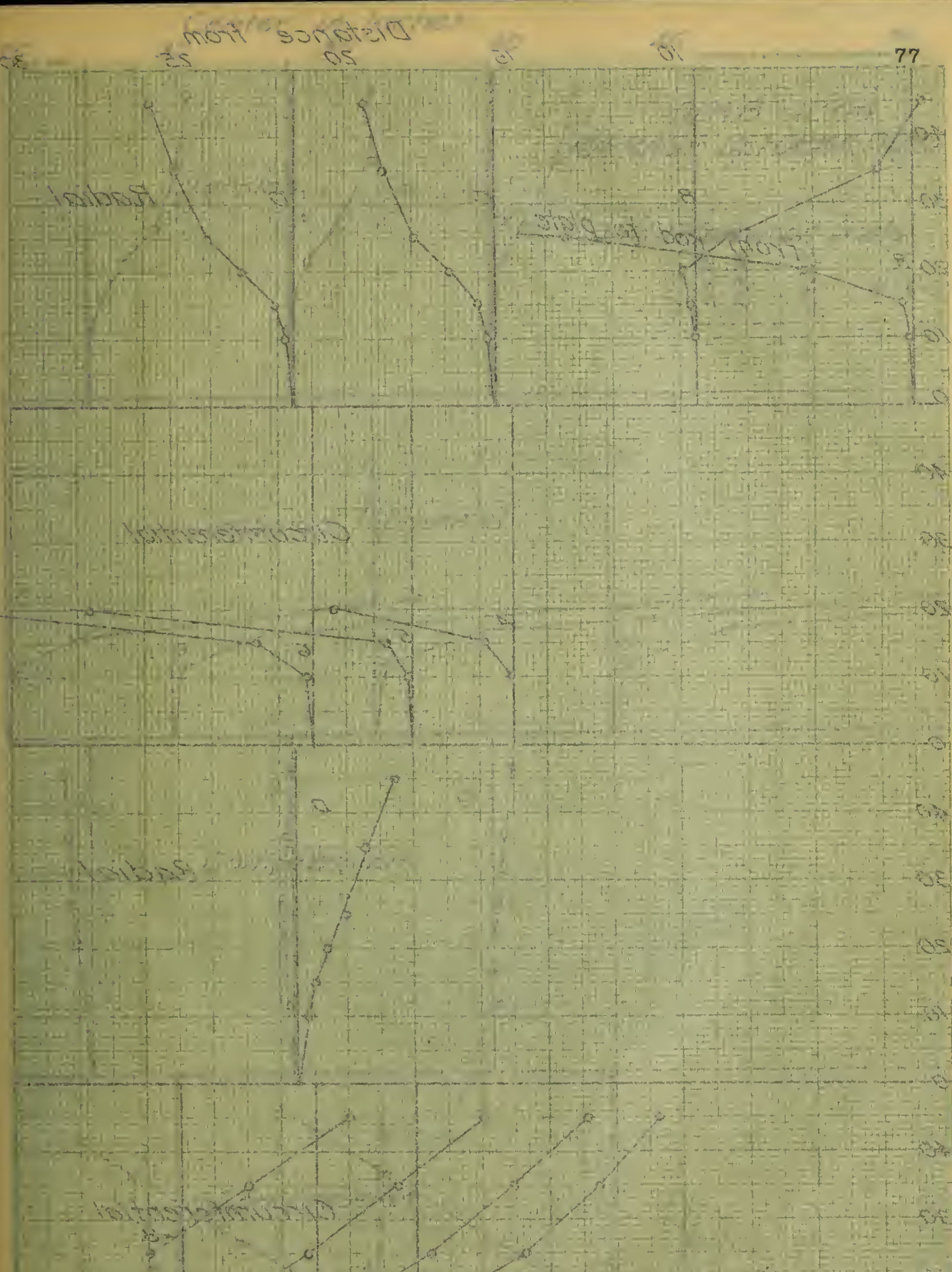


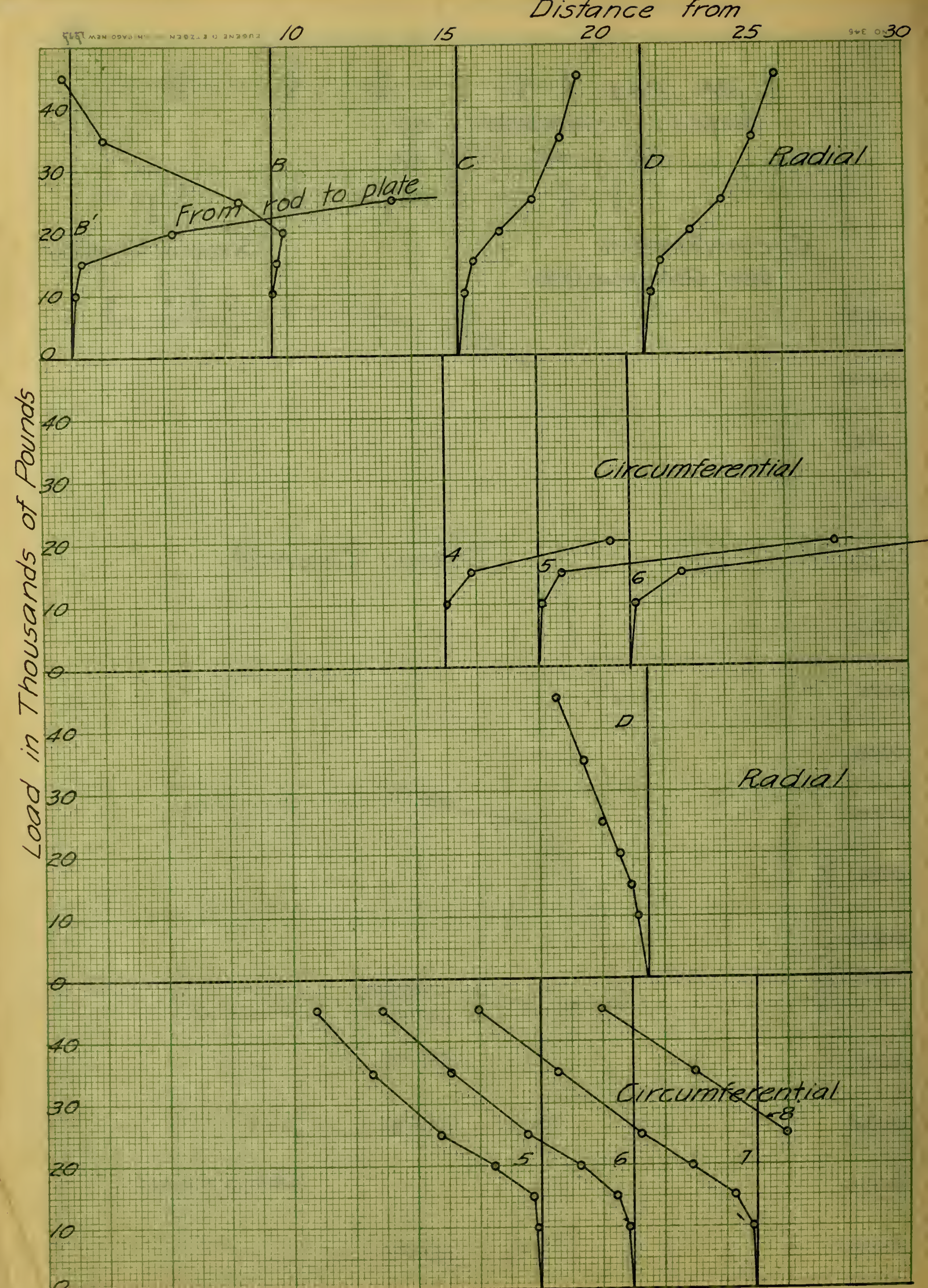
SLAB 1243
Radial Reinforcement Only
Max. Load 50000 lb.
5 6 7 8 9 10
4 5 6 7 8 9 10
Scale of Drawing
0 2 in. 4 in. 8 in.
Circumferential
Unit Deformations
.0022
.0020
.0018
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
Unit Deformation
25000
Tension (Concrete)
20000
10000
10000
20000
25000
Compression
35000

NO 345

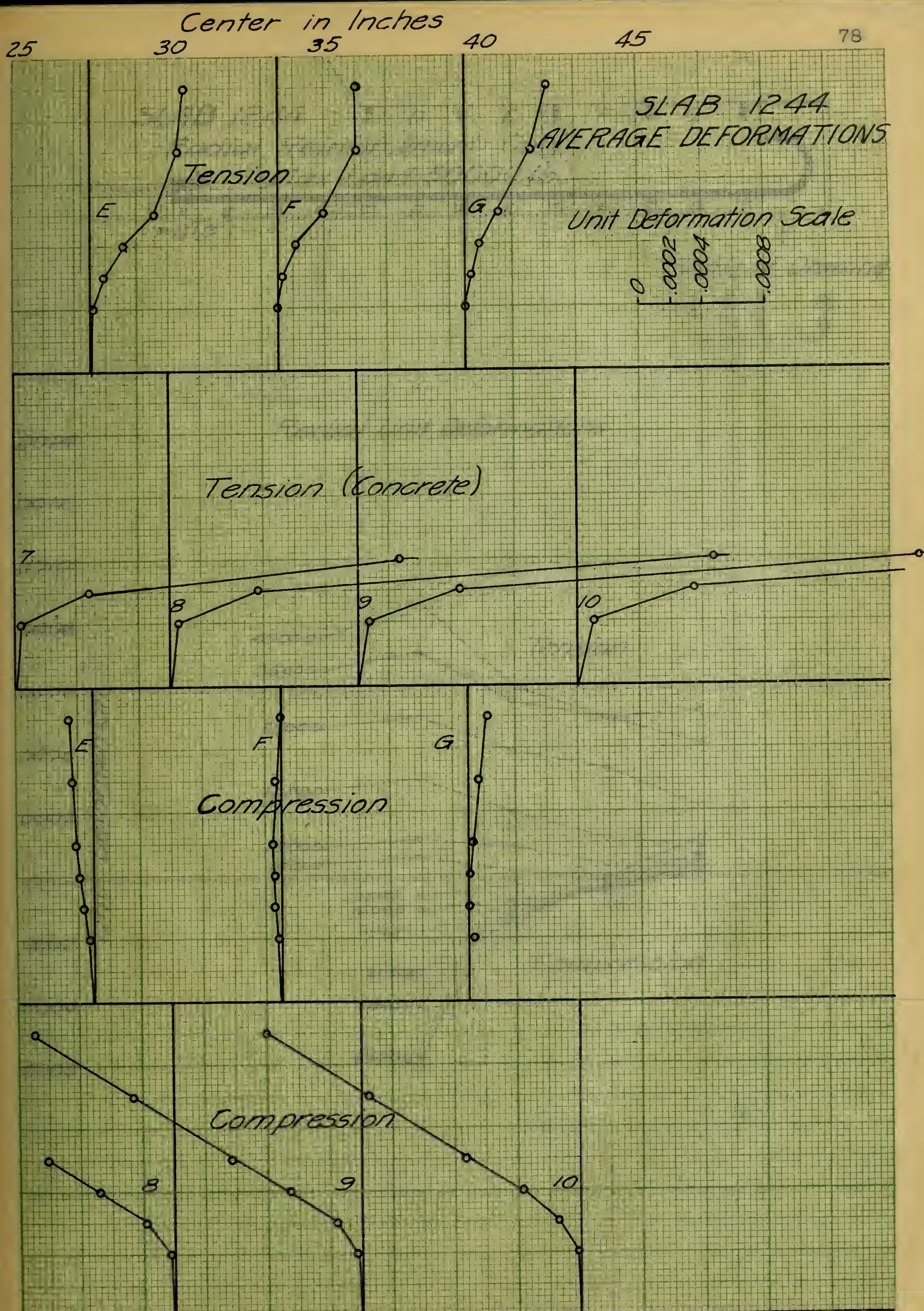


SLAB 1243
Radial Reinforcement Only
Max Load 50000 lb
Circumferential Unit Deformations
Scale of Drawing
Tension (Concrete)
Compression
Unit Deformation
25000
20000
10000
10000
20000
25000
35000
.0022
.0020
.0018
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008

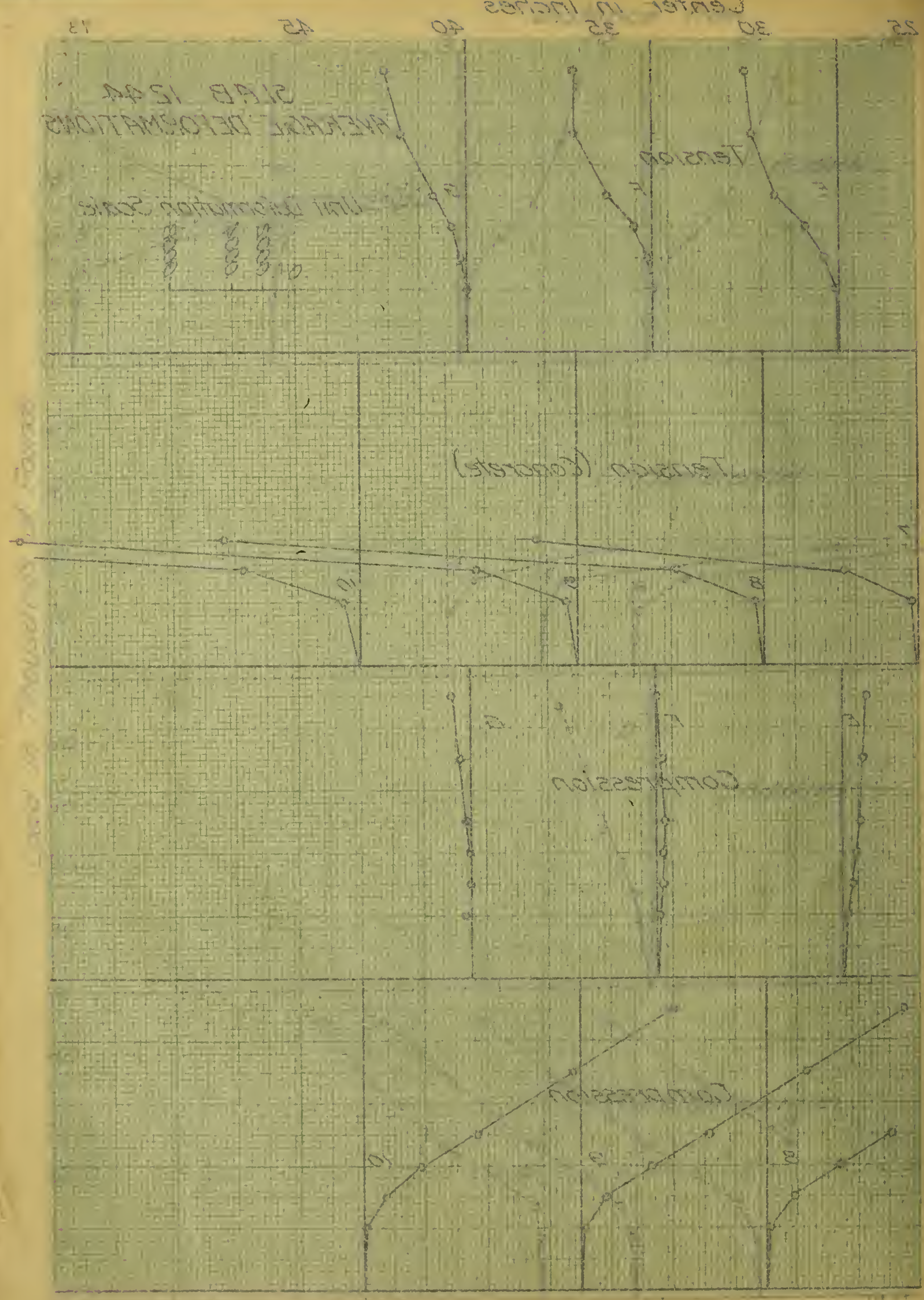

Distance from
Load in Thousands of Pounds
Radial
Circumferential



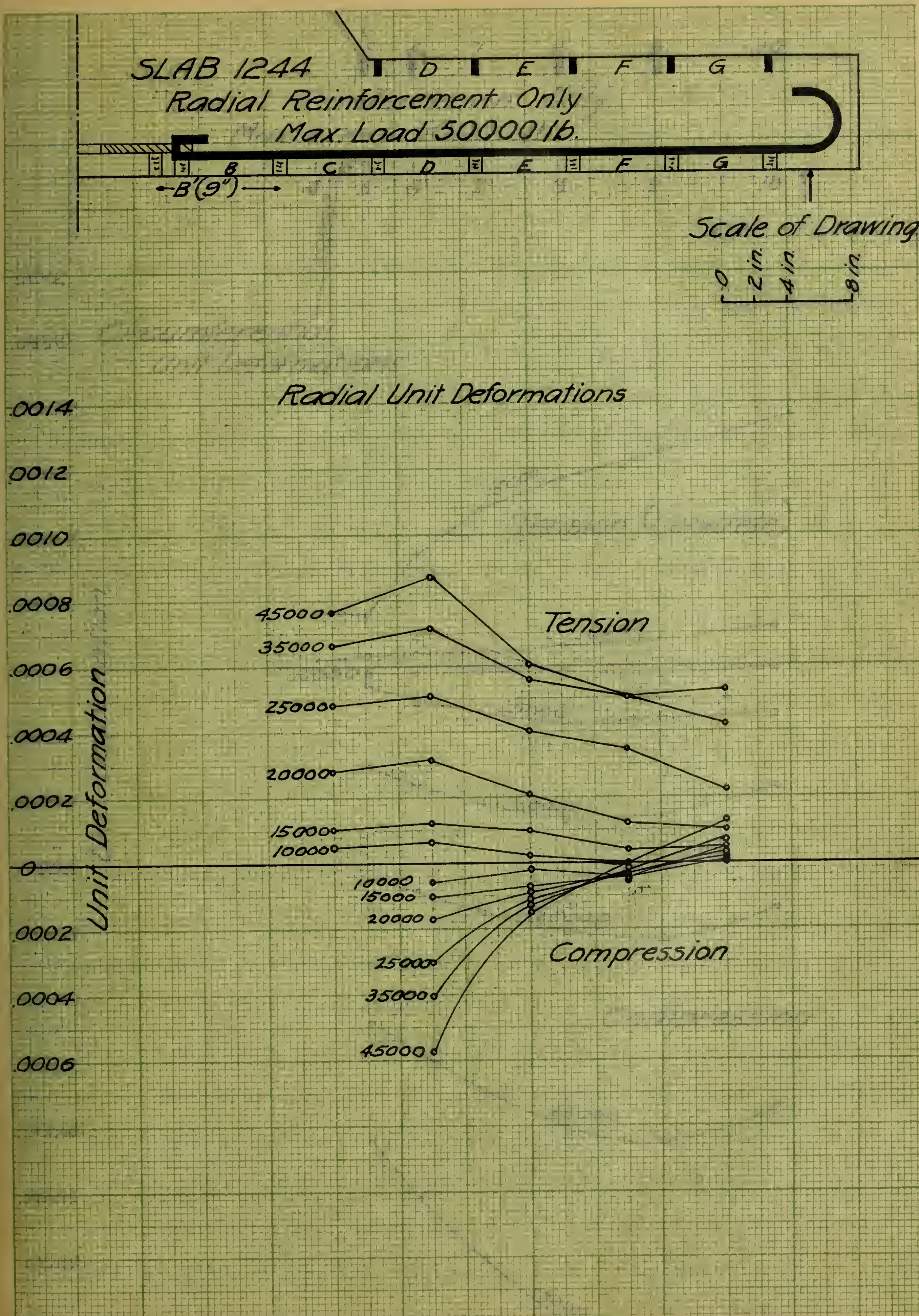
Distance from
10
15
20
25
30
Load in Thousands of Pounds
B′
B
C
D
From rod to plate
Radial
Circumferential
4
5
6
D
Radial
Circumferential
5
6
7
8

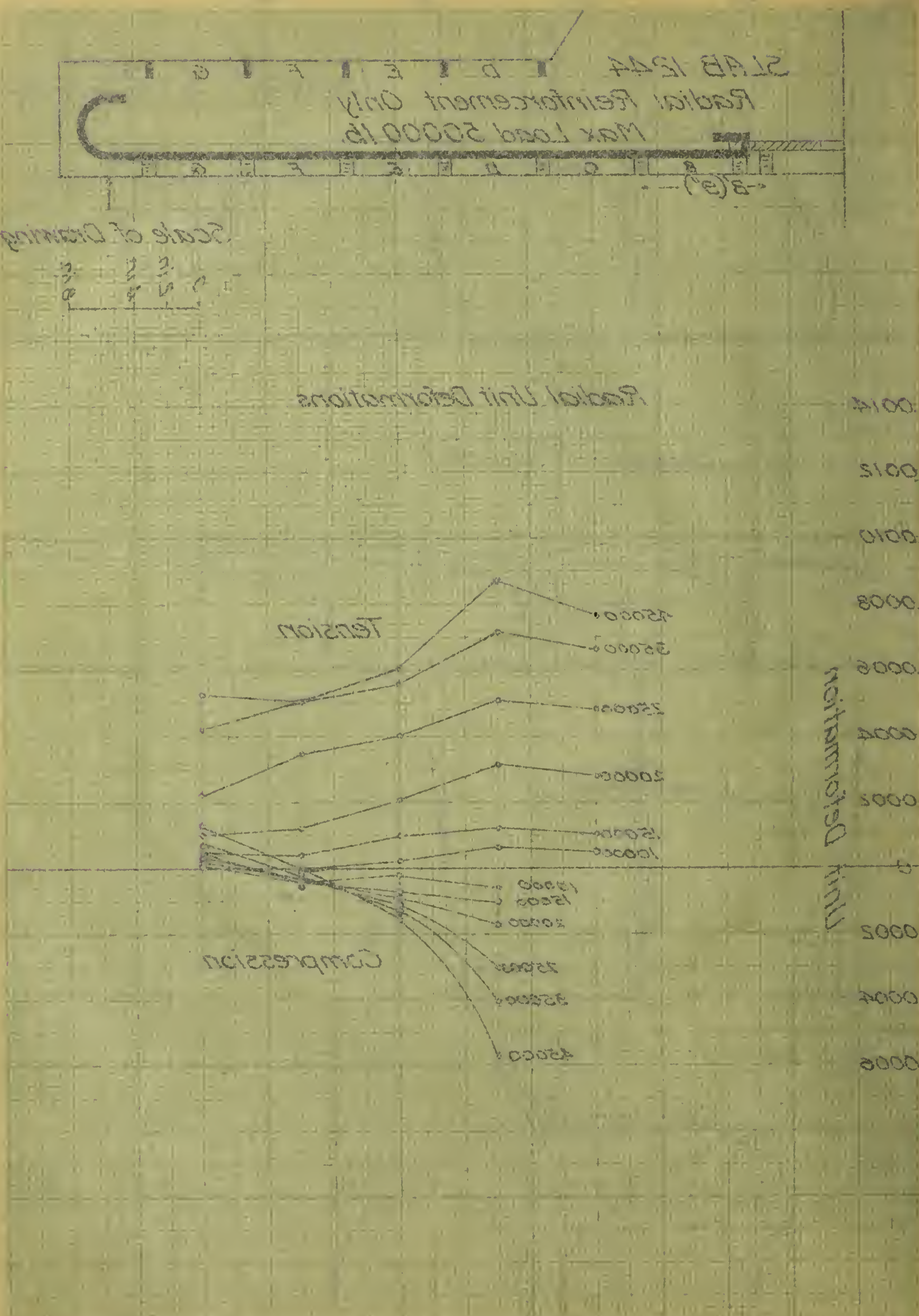


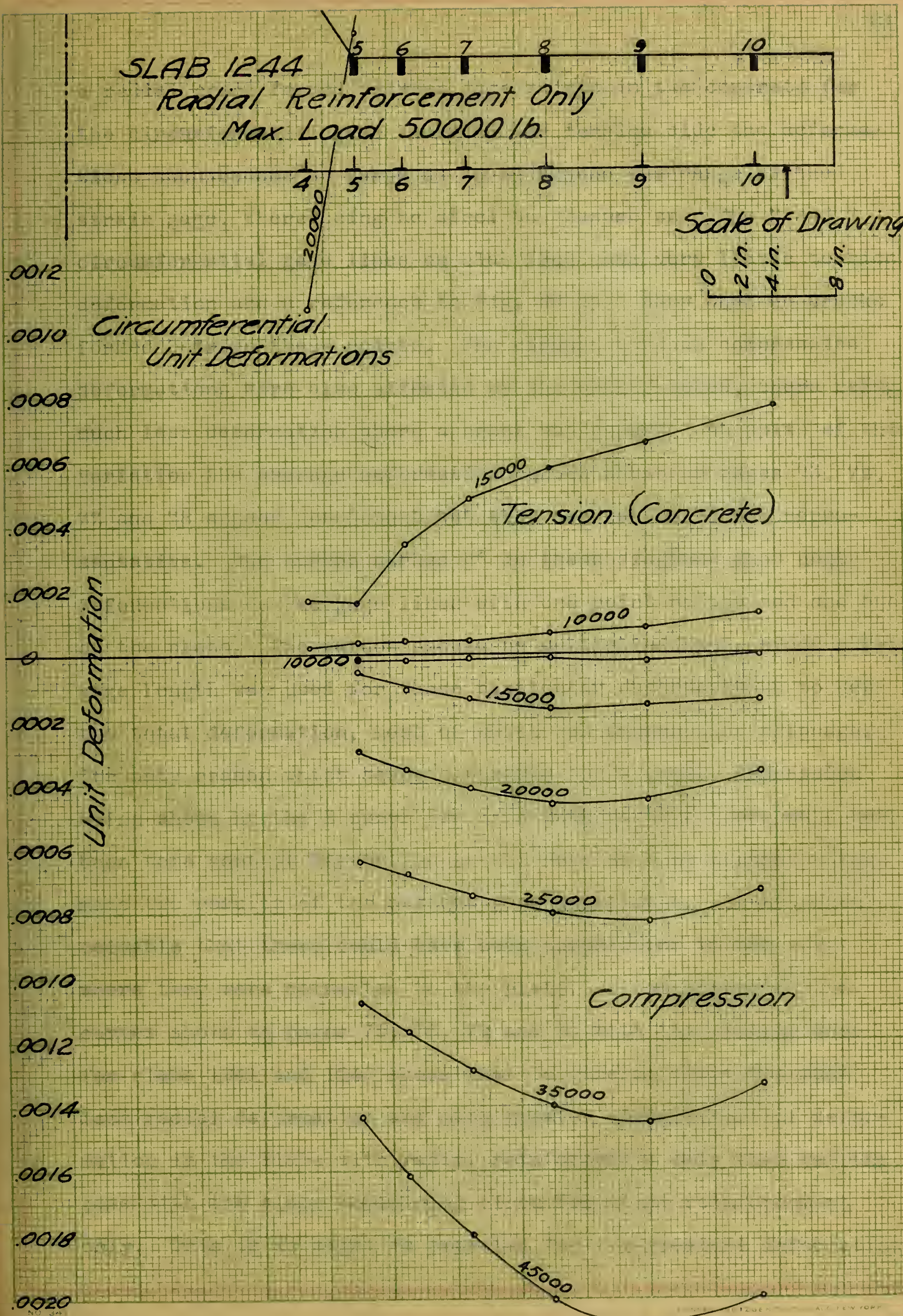
Center in Inches
25
30
35
40
45
SLAB 1244
AVERAGE DEFORMATIONS
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E
F
G
Tension (Concrete)
7
8
9
10
Compression
E
F
G
Compression
8
9
10

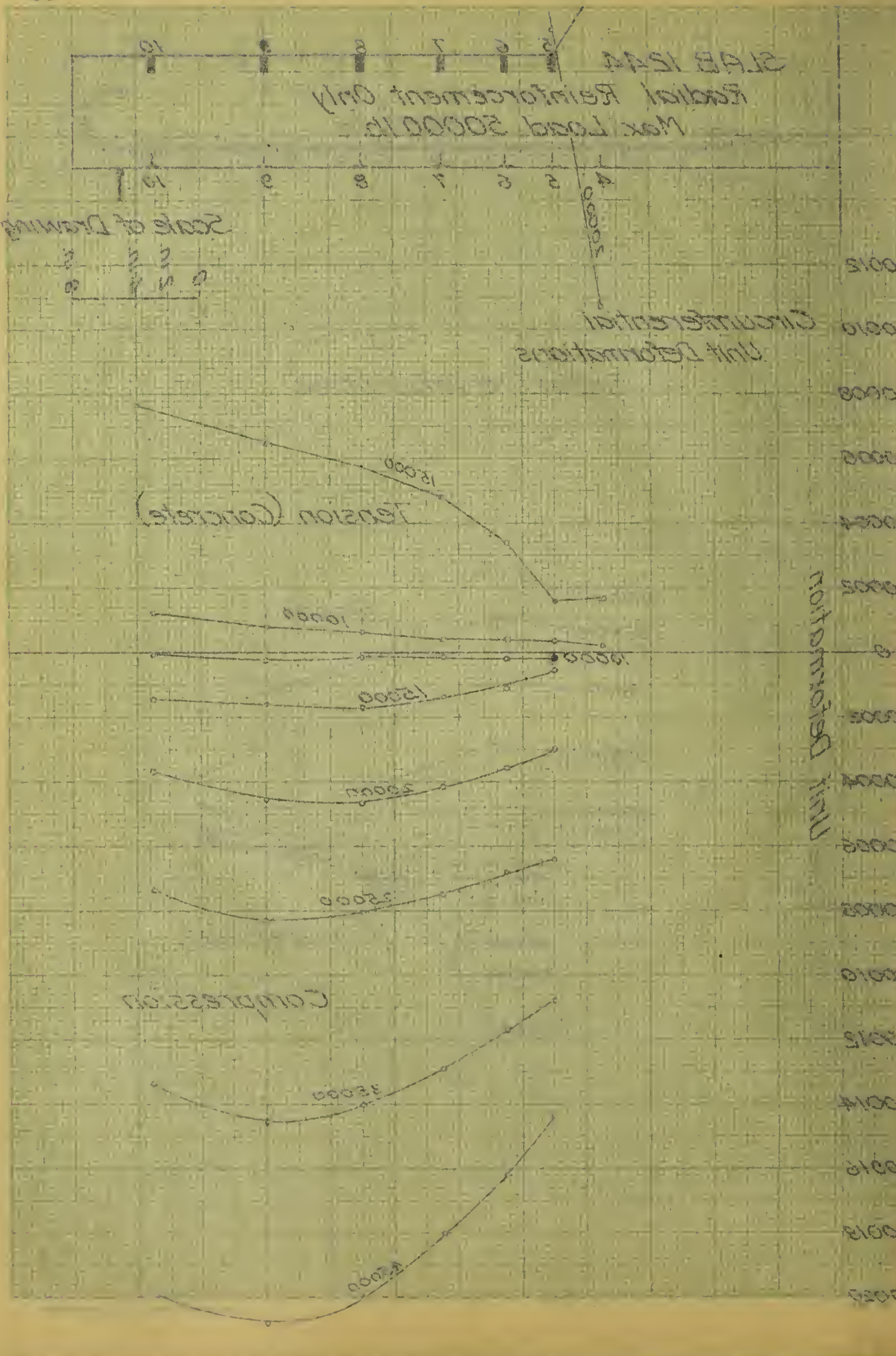


Center in inches
25
30
35
40
45
SLAB 1244
AVERAGE DEFORMATIONS
Unit Deformation Scale
Tension
Tension (Concrete)
Compression
Compression


SLAB 1244
Radial Reinforcement Only
Max. Load 50000 lb.
B C D E F G
B (9")
Scale of Drawing
0 2 in. 4 in. 8 in.
Radial Unit Deformations
Unit Deformation
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
Tension
Compression
45000
35000
25000
20000
15000
10000
10000
15000
20000
25000
35000
45000


SLAB 1244
Radial Reinforcement Only
Max Load 50000 lb.
Scale of Drawing
Radial Unit Deformations
Tension
Compression
Unit Deformation
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
45000
35000
25000
20000
15000
10000
10000
15000
20000
25000
35000
45000


SLAB 1244
Radial Reinforcement Only
Max. Load 50000 lb.
Scale of Drawing
0 2 in. 4 in. 8 in.
Circumferential
Unit Deformations
Tension (Concrete)
Compression
Unit Deformation
15000
10000
10000
15000
20000
25000
35000
45000
20000
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020


SLAB 1244
Radial Reinforcement Only
Max Load 30000 lb
Scale of Drawing
Circumferential Unit Deformations
Tension (Concrete)
Compression
Unit Deformation
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020
18000
10000
15000
20000
25000
35000
2000
10
9
8
7
6
5
4

a radial crack formed between gage points in the concrete for the circumferential gage lines on the tension side the deformations soon became so large as to be beyond the range of the strain gage, there being no steel to measure on. The N and S circumferential gage lines on slab 1243 gave very little tension deformation and a reference to Fig. 27 will show that no cracks formed between these points. The circumferential compression deformations were also affected by the cracks below, there being much less deformation where a crack was absent. In spite of this variation the average deformation curves shown on pages 73, 74, 77, and 78 appear consistent but they may not be at all representative. The curves marked B' in these diagrams show unit deformations on the gage lines with one point on the rod and one on the plate. The values should be multiplied by 9, since a 9-in. gage length was used for those particular observations, to get the total deformation, most of which was undoubtedly slippage. The only reason which seems plausible for a large compression being shown by the B curve for slab 1244 is that there must have been some sort of distortion in the rods as they slipped which made the results of the observations unreliable. It is inconceivable that there could have been compression in the rods where they were connected to the plate. A comparison of the curves shown on pages 75, 76, 79, and 80 with the similar ones for slabs 1241 and 1242 shows that in general there was much less radial deformation and much greater circumferential deformation in the slabs with radial reinforcement only than was the case with the slabs containing circumferential reinforcement only. This is as might be expected for the greatest deformation

would be most likely to occur where there was no steel to resist it.

C. SLABS WITH CIRCUMFERENTIAL AND RADIAL REINFORCEMENT.

17. Phenomena of Tests.- Figs. 30, 32, and 33 show the manner of formation of cracks on the tension sides of slabs 1245 and 1246. The first cracks formed at a load of 20 000 lb. and opened but slightly at higher loads. As the load was increased new cracks formed from time to time but remained small up to the ultimate. They followed the radial and circumferential rods, the circumferential cracks being tangent ot the outside perimeters of the hoops as was the case in slabs 1241 and 1242 with circumferential reinforcement only. These slabs failed by punching through from the edges of the column capitals above to the lines marked "rupture" in Figs. 30 and 33 after the radial steel had been stressed to the yield point and the outer hoops even higher. Fig. 31 shows the appearance of the bottom of slab 1246 after the test. Slab 1245 could not be photographed in this manner because the absence of the lifting loops made the task of turning this slab on edge both difficult and dangerous.

18. Load-deformation Relations.- The load-deformation curves for slabs 1245 and 1246 show very uniform results for gage lines placed symmetrically with respect to the centers. The average deformation curves on pages 87, 88, 91, and 92 are very consistent. The unit deformations in the radial steel increased from the center to points a little outside the edge of the column capital, then decreased slowly. The radial compression deformations decreased very rapidly with the distance out from the edge of

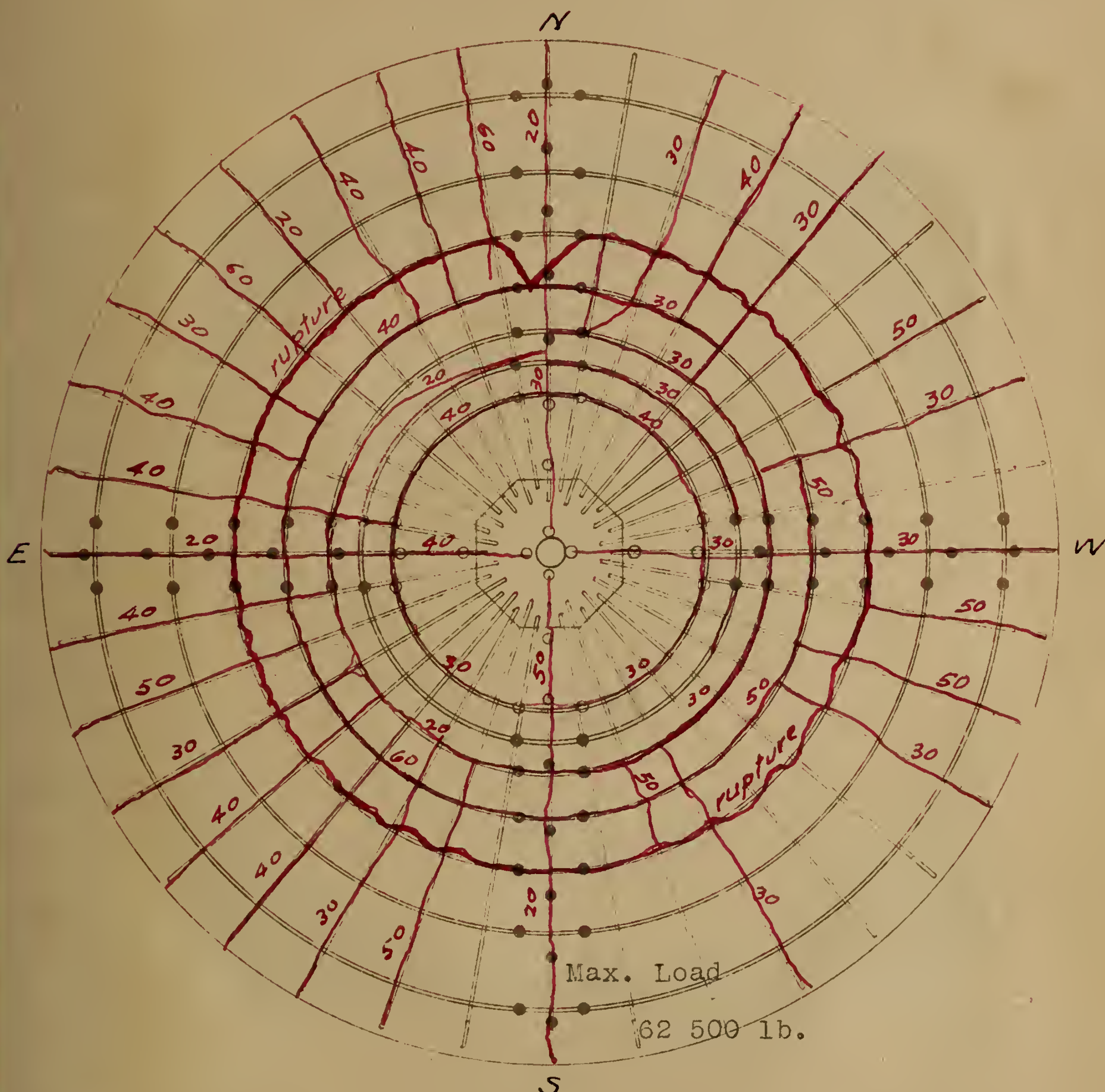


Fig.30. Slab 1245.-Location of Cracks.

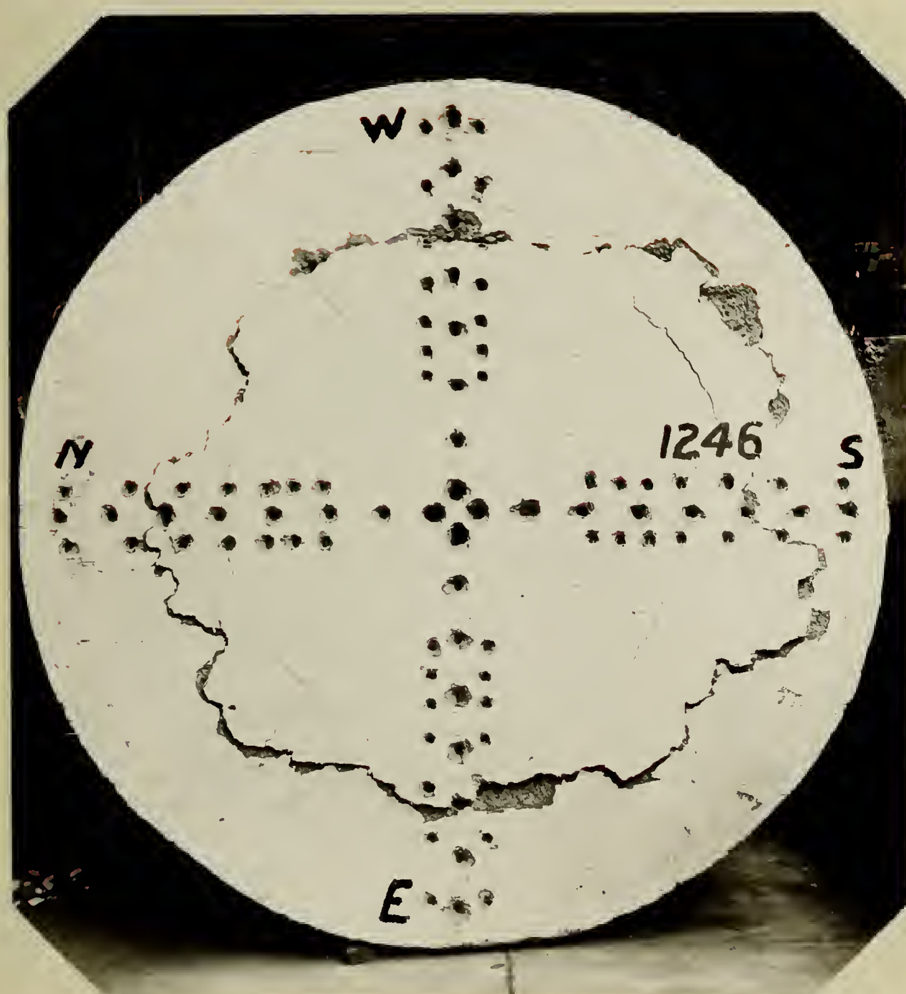


Fig.31. Slab 1246.-View Showing Manner of Failure.

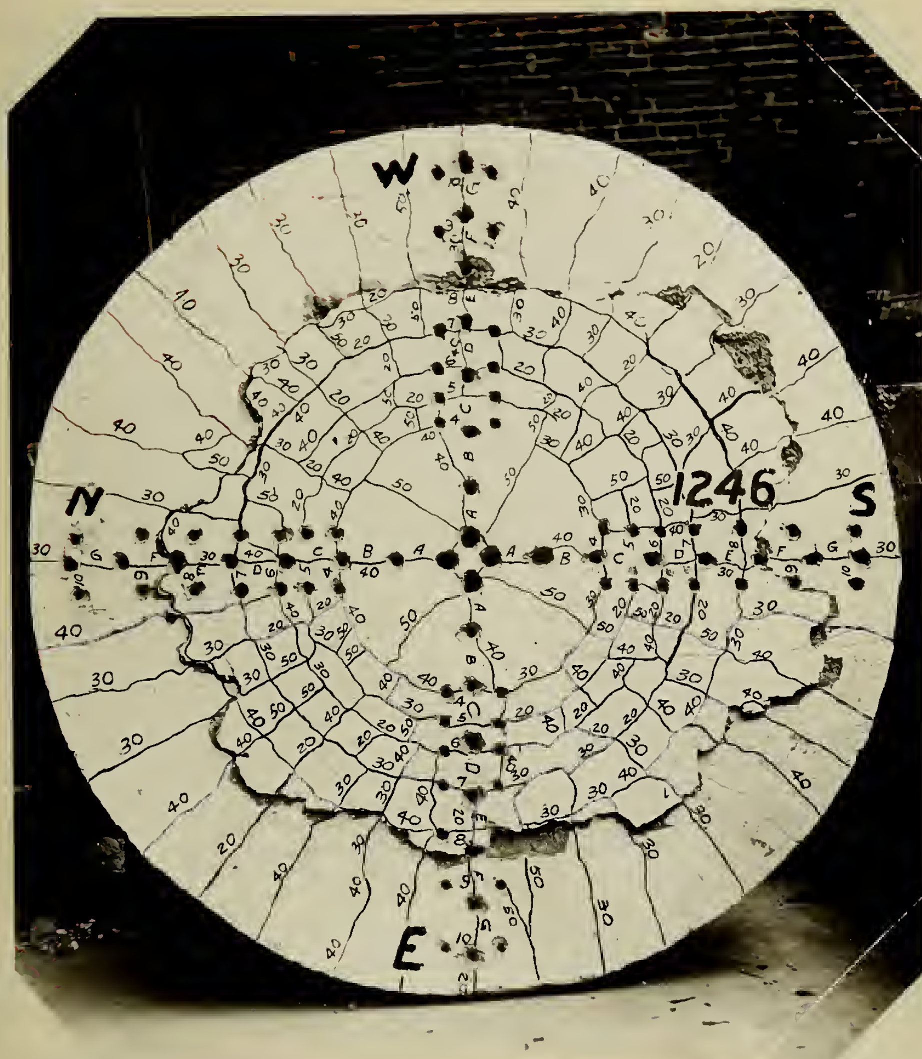


Fig.32. Slab 1246.-View Showing Location of Cracks.

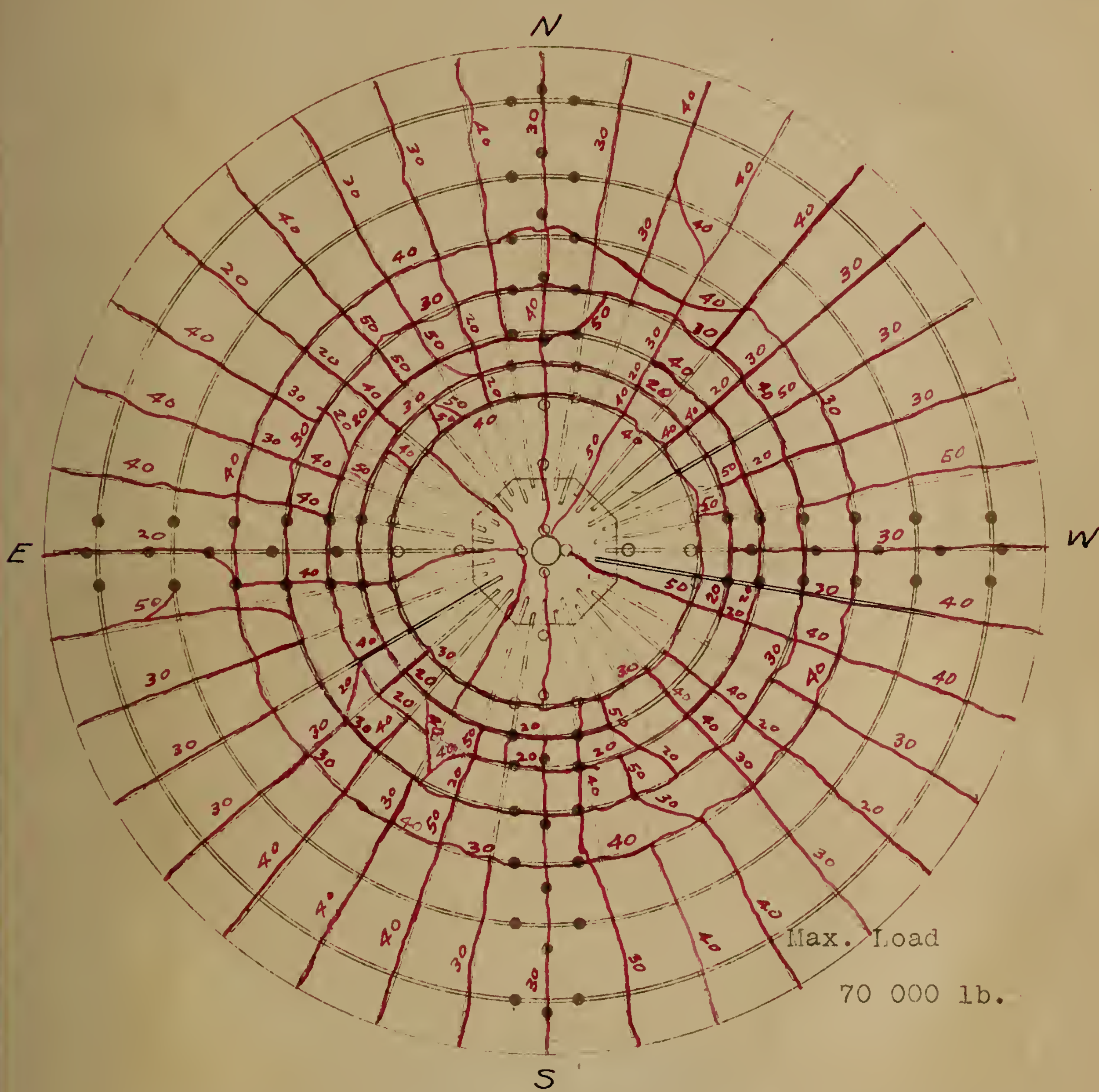
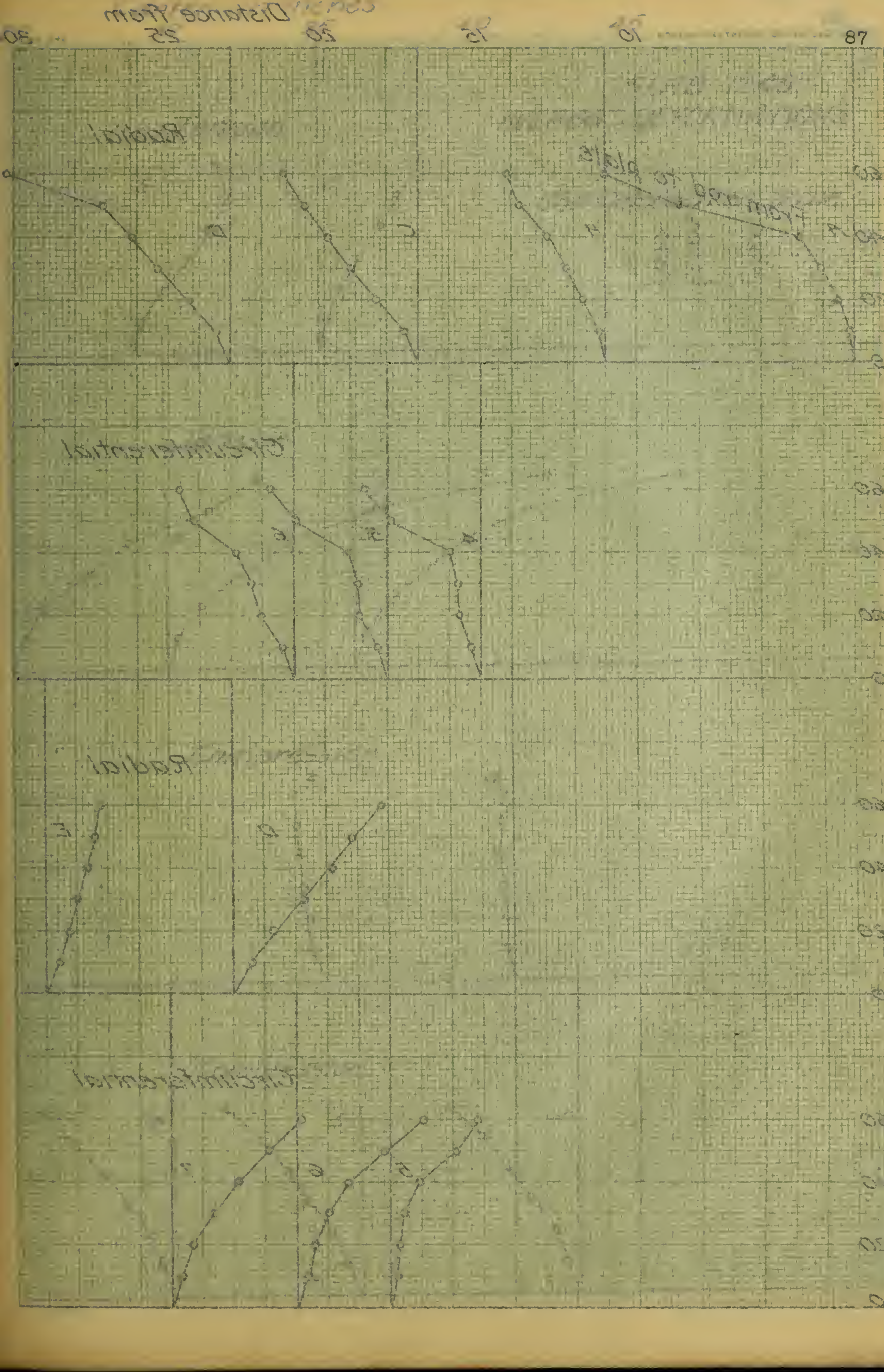
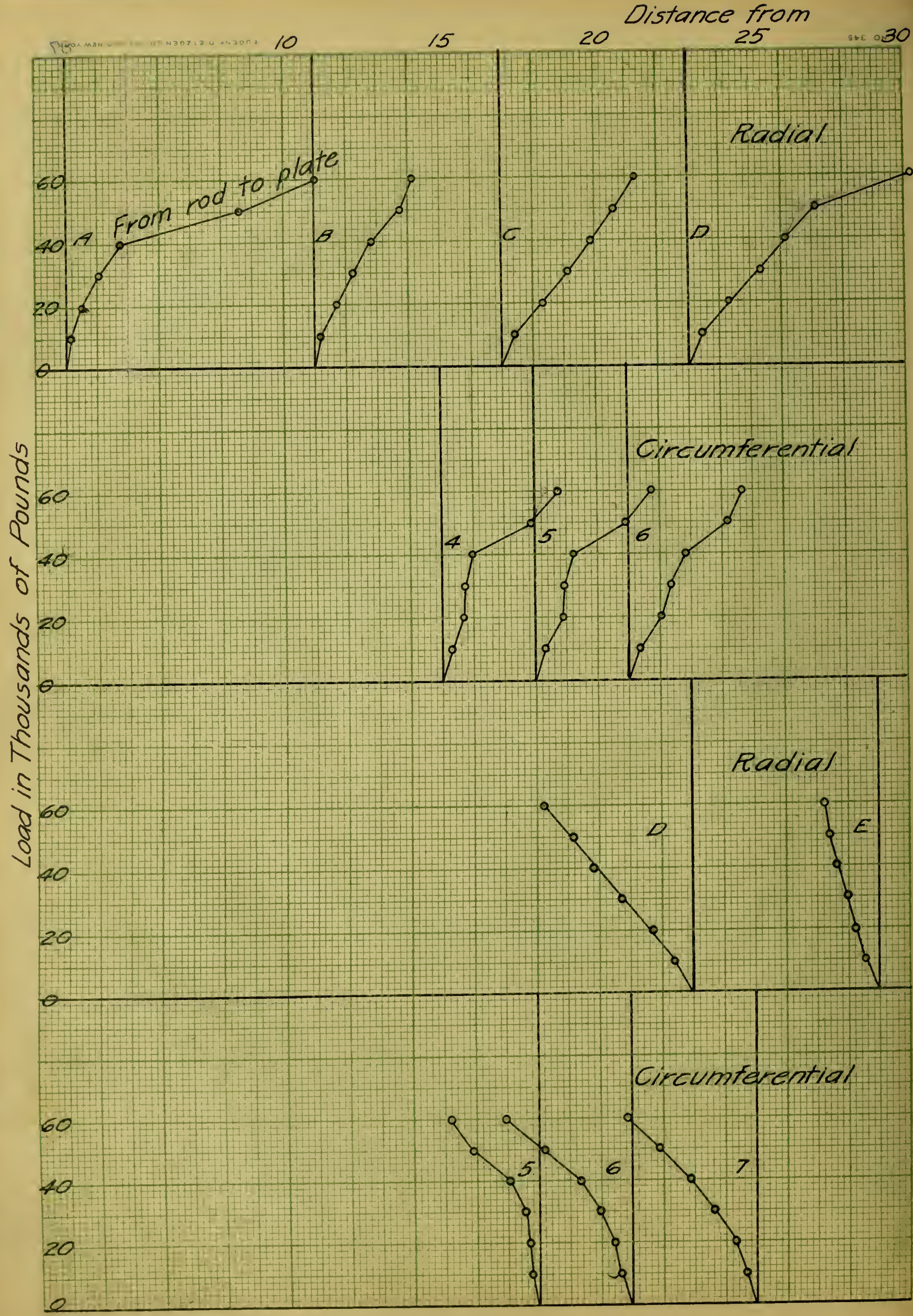
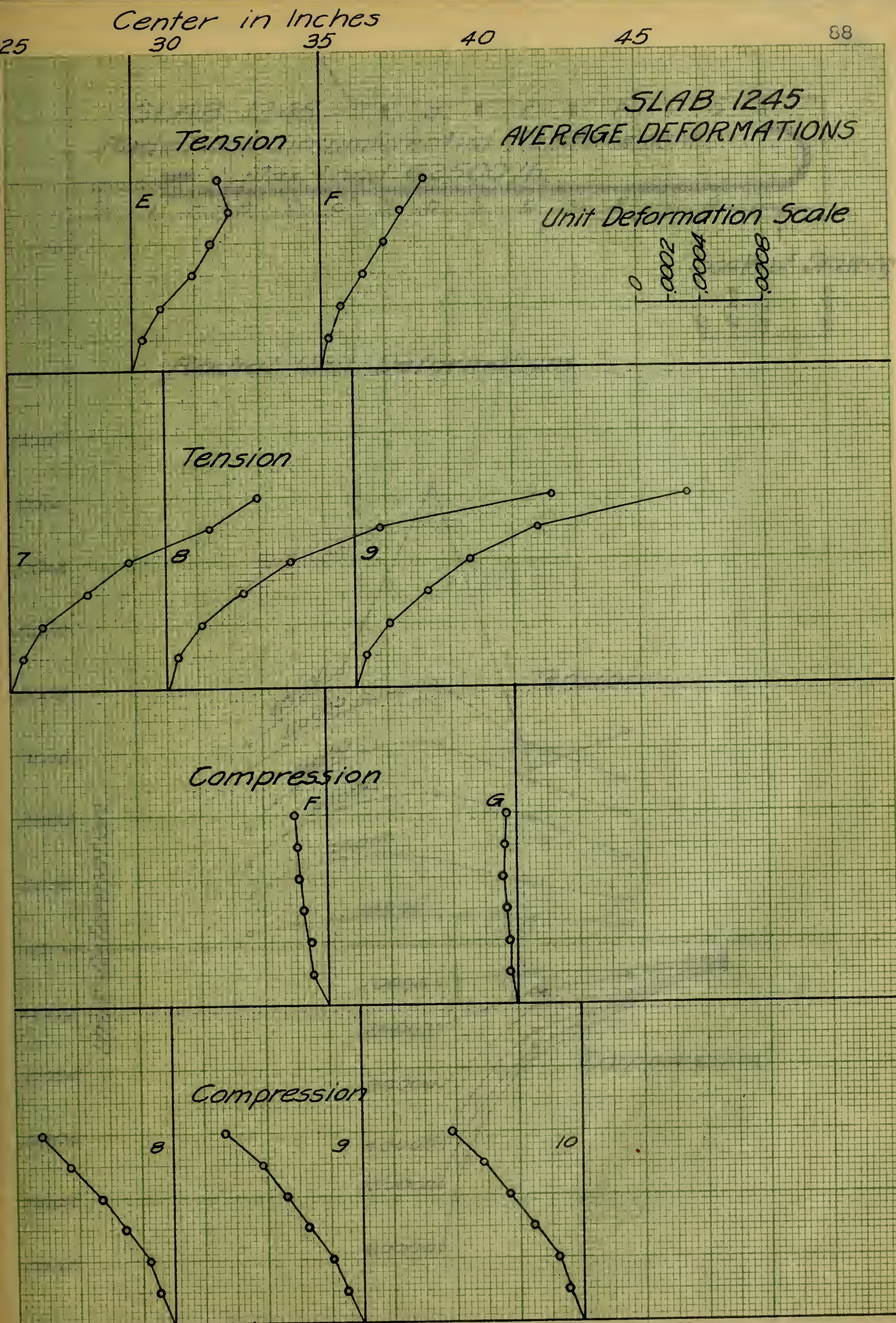


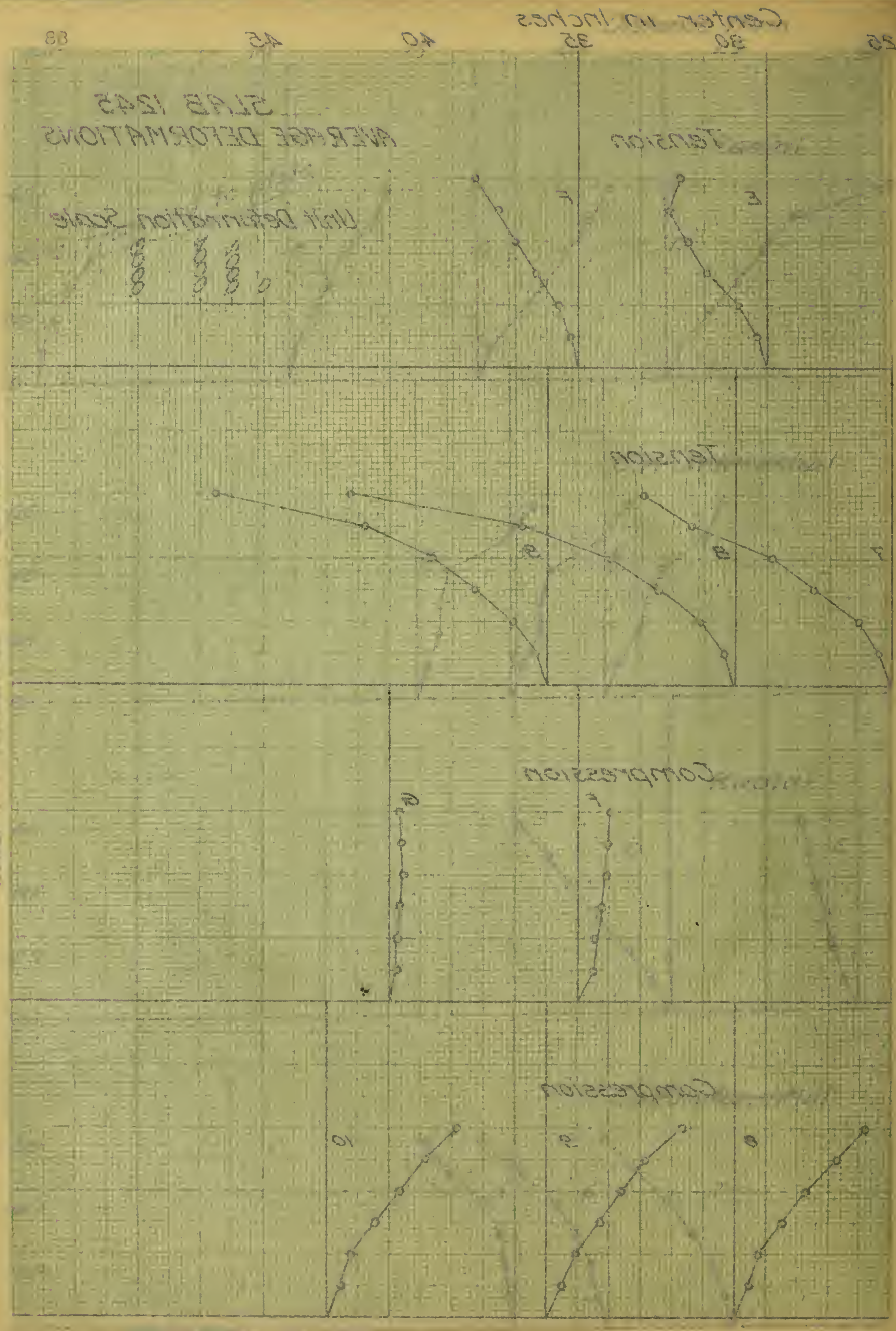
Fig.33. Slab 1246.-Sketch Showing Location of Cracks.

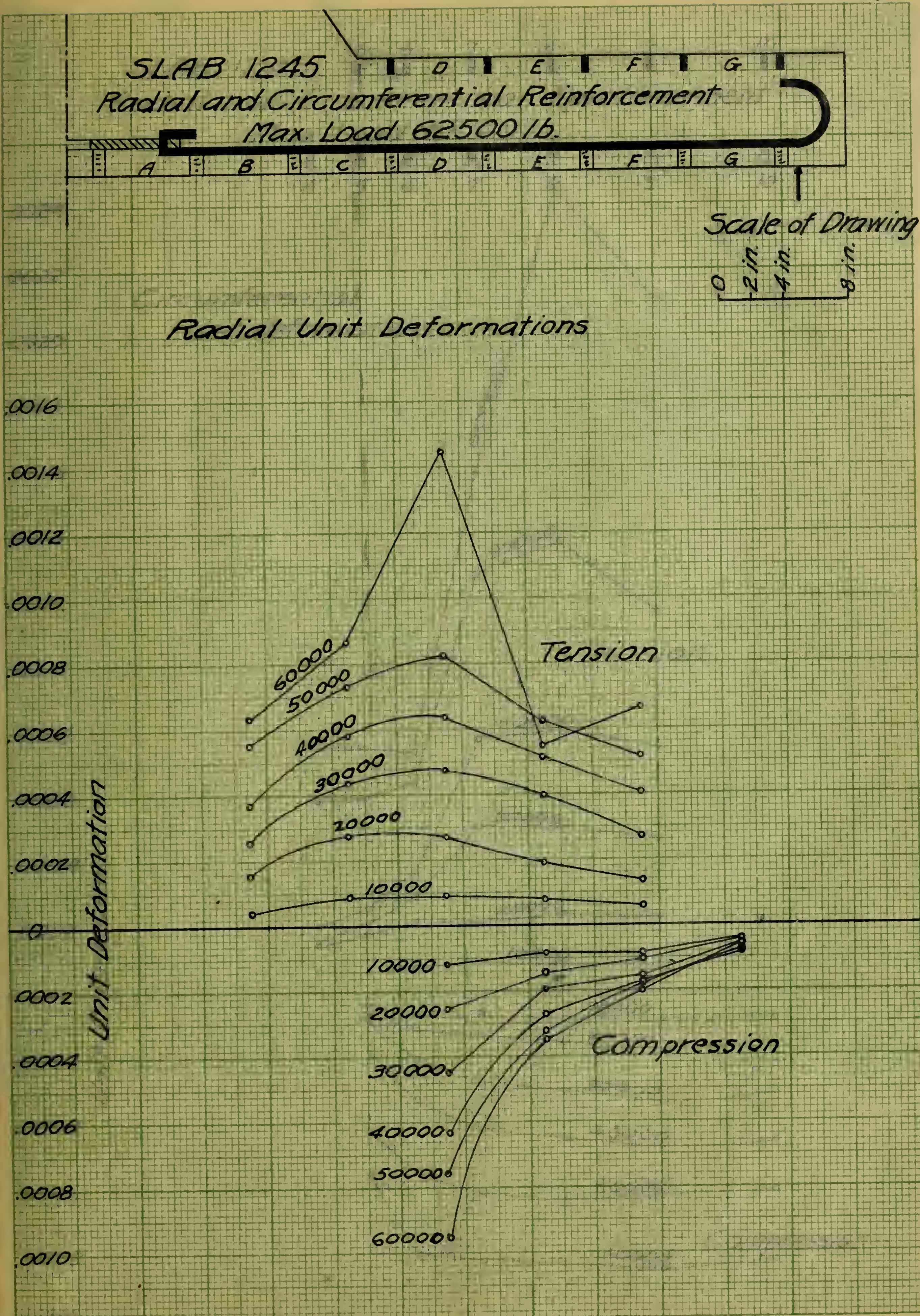

Distance from
Radial
Circumferential
Radial
Circumferential
Framing to plate
Load in Thousands of Pounds

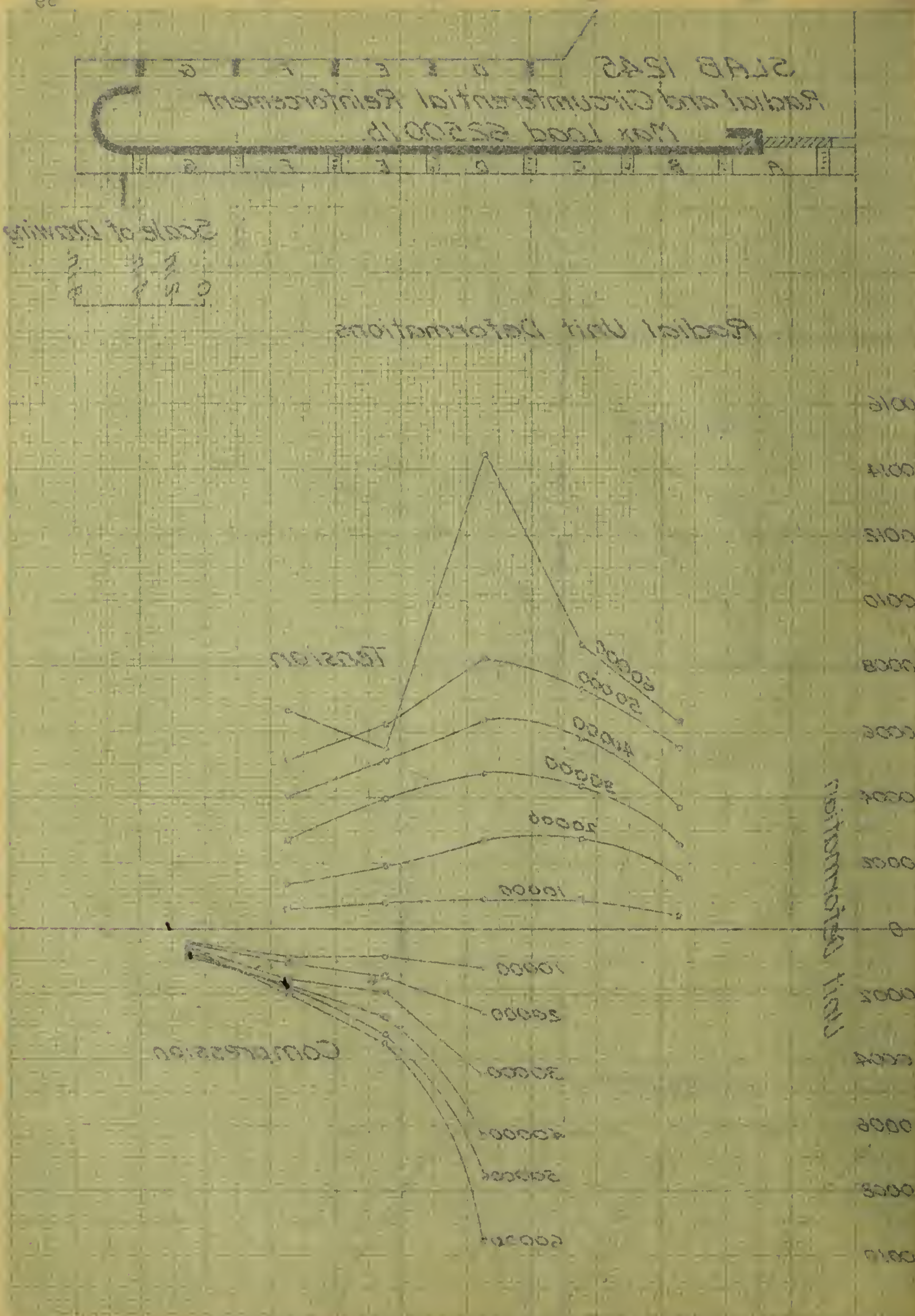


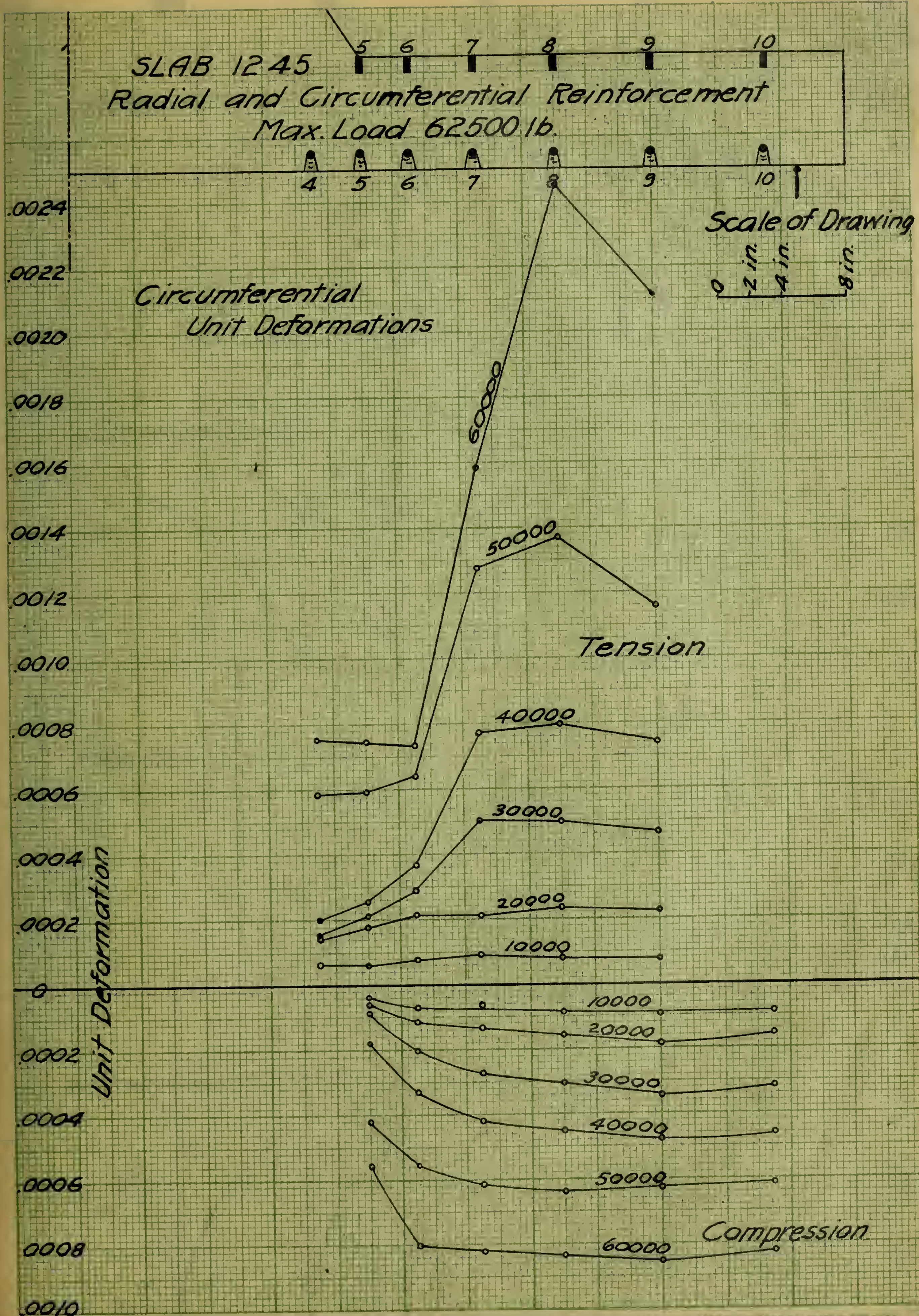
Distance from
10
15
20
25
30
Radial
From rod to plate
A
B
C
D
Circumferential
4
5
6
Radial
D
E
Circumferential
5
6
7
Load in Thousands of Pounds
0
20
40
60

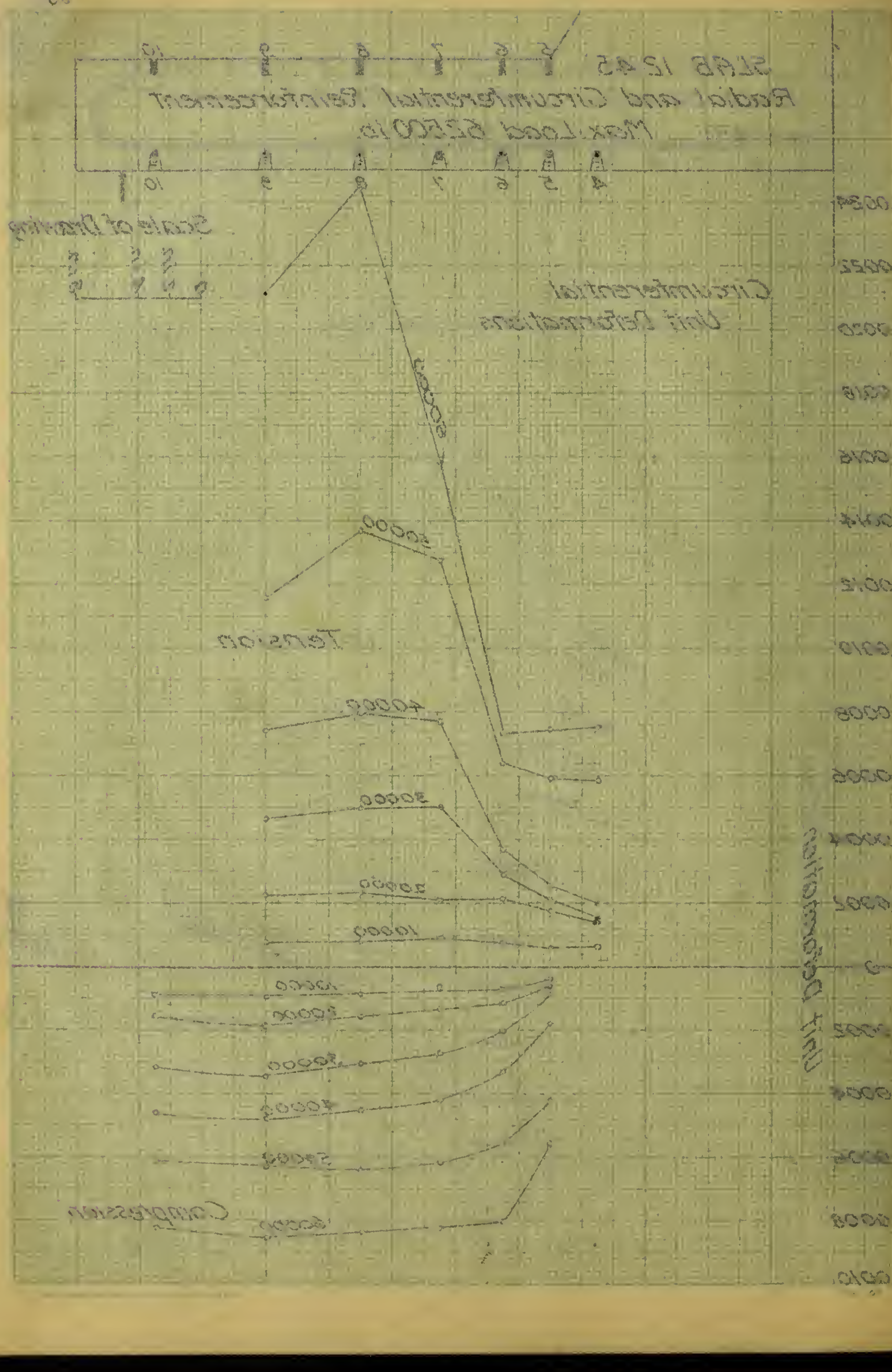

Center in Inches
25
30
35
40
45
SLAB 1245
AVERAGE DEFORMATIONS
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E
F
Tension
7
8
9
Compression
F
G
Compression
8
9
10

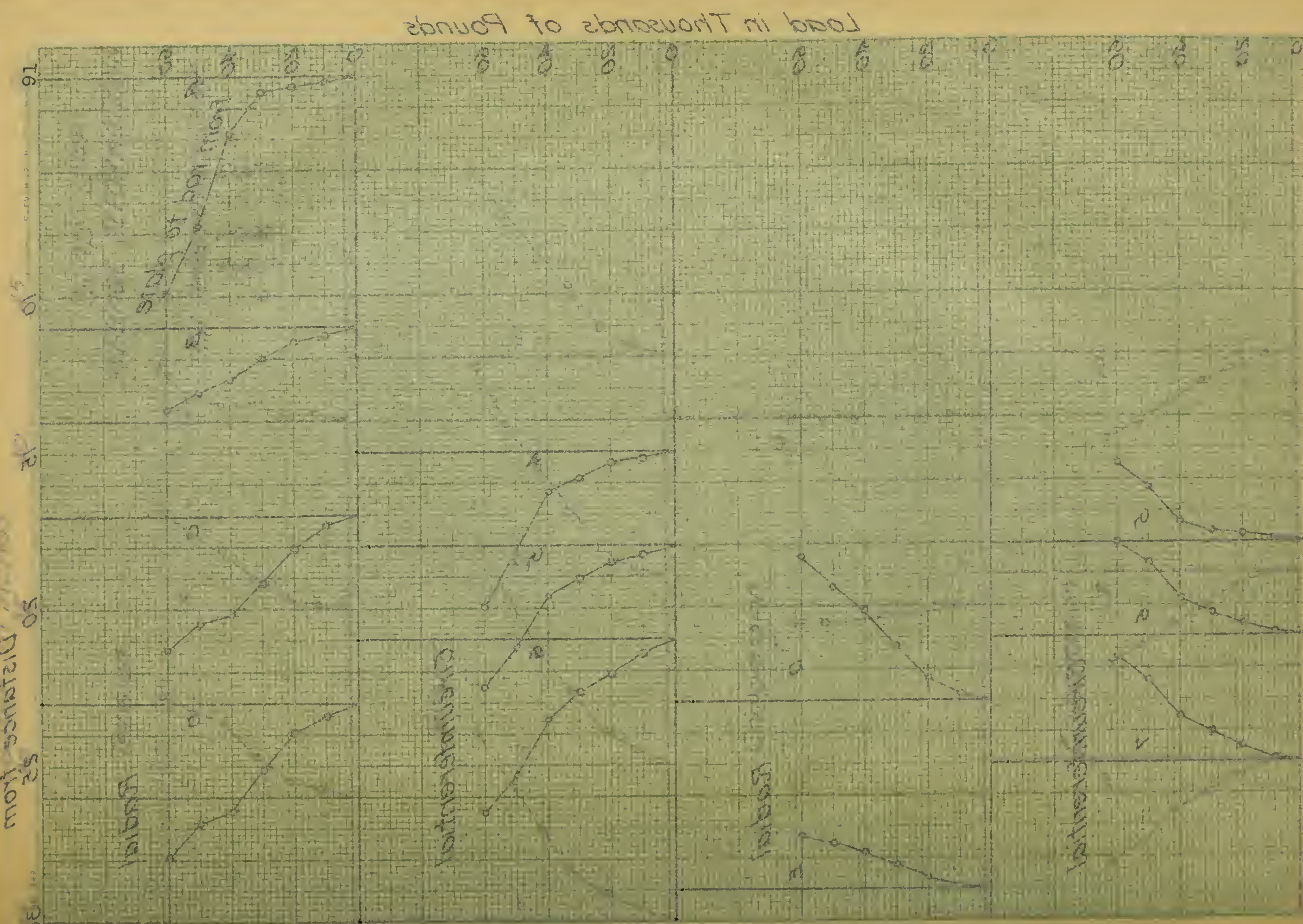

SLAB 1245
AVERAGE DEFORMATIONS
Unit Deformation Scale
Center in Inches
25
30
35
40
45
Tension
Tension
Compression
Compression

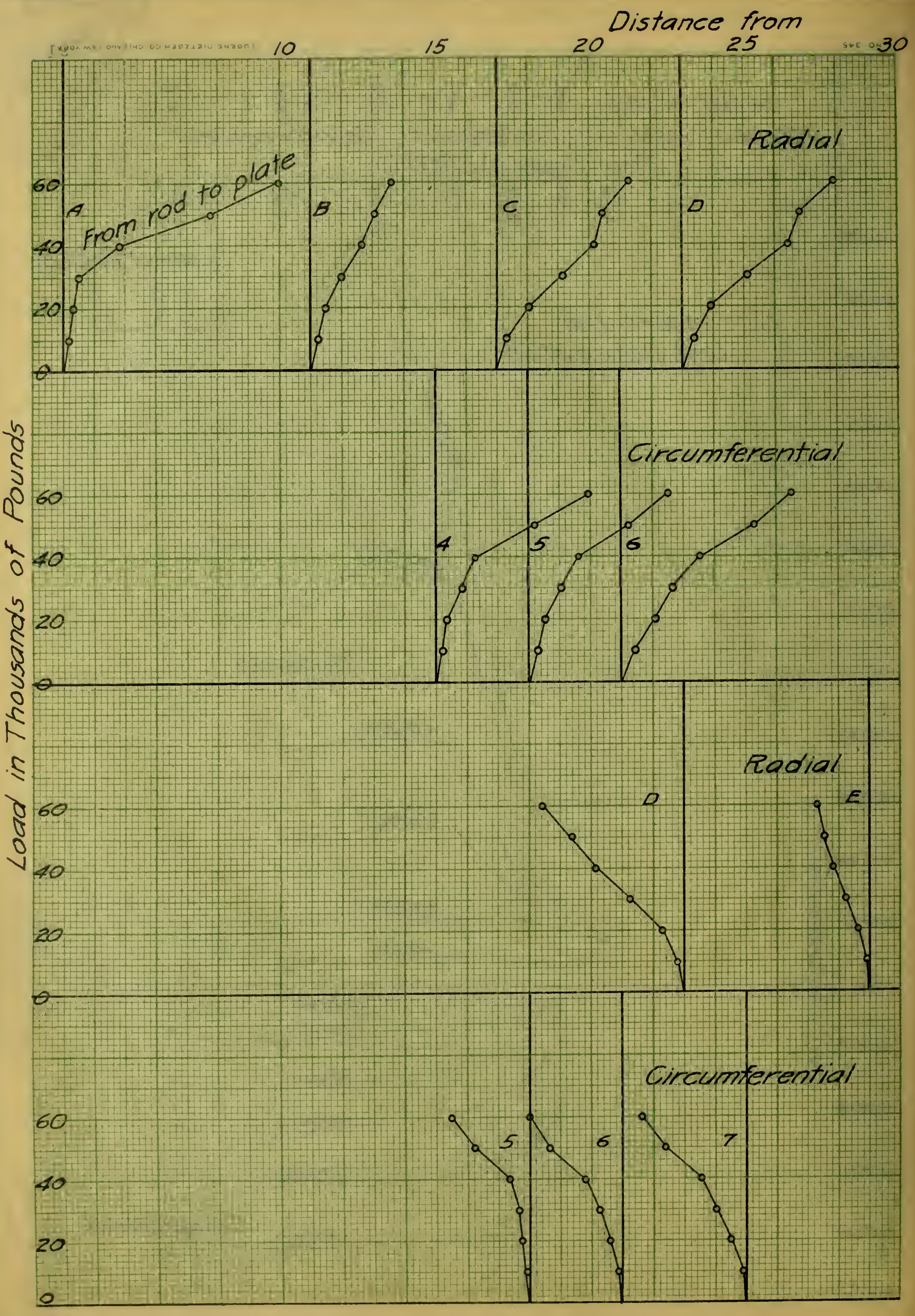

SLAB 1245
Radial and Circumferential Reinforcement
Max. Load 62500 lb.
A B C D E F G
Scale of Drawing
0 2 in. 4 in. 8 in.
Radial Unit Deformations
Unit Deformation
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
Tension
60000
50000
40000
30000
20000
10000
Compression
10000
20000
30000
40000
50000
60000


SLAB 1245
Radial and Circumferential Reinforcement
Max Load 62500 lb.
Scale of Drawing
Radial Unit Deformations
Tension
Compression
Unit Deformation
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
60000
50000
40000
30000
20000
10000

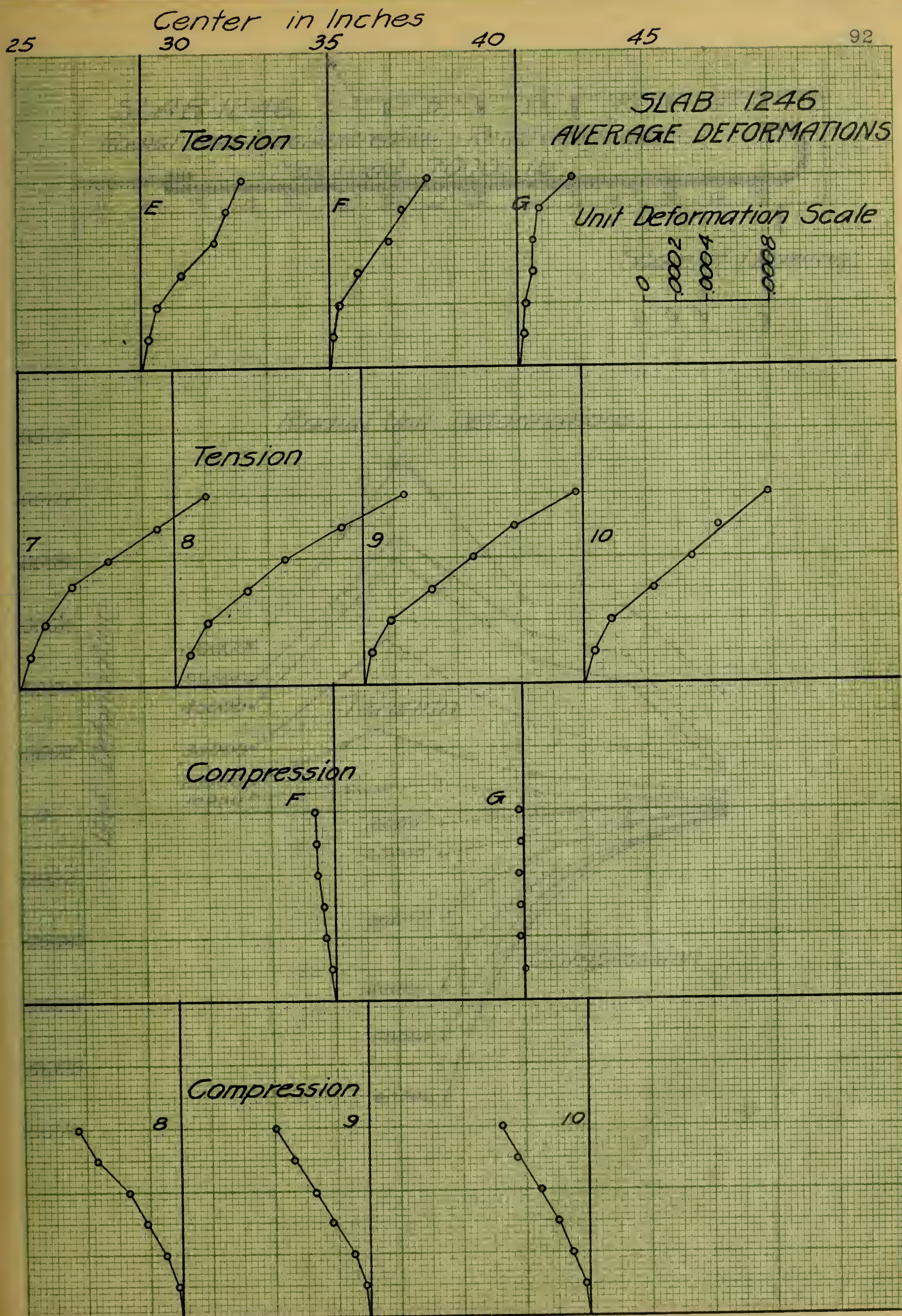

SLAB 12.45
Radial and Circumferential Reinforcement
Max. Load 62500 lb.
Circumferential
Unit Deformations
Scale of Drawing
0 2 in. 4 in. 8 in.
Tension
Compression
Unit Deformation
.0024
.0022
.0020
.0018
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
4 5 6 7 8 9 10
60000
50000
40000
30000
20000
10000


Radial and Circumferential Reinforcement
Scale of Drawing
Circumferential
Unit Deformations
Tension
Compression
Unit Deformations
.0024
.0022
.0020
.0018
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
60000
50000
40000
30000
20000
10000


Load in Thousands of Pounds
Distance from center, inches
Radial
Circumferential
Radial
Circumferential
from rod to plate

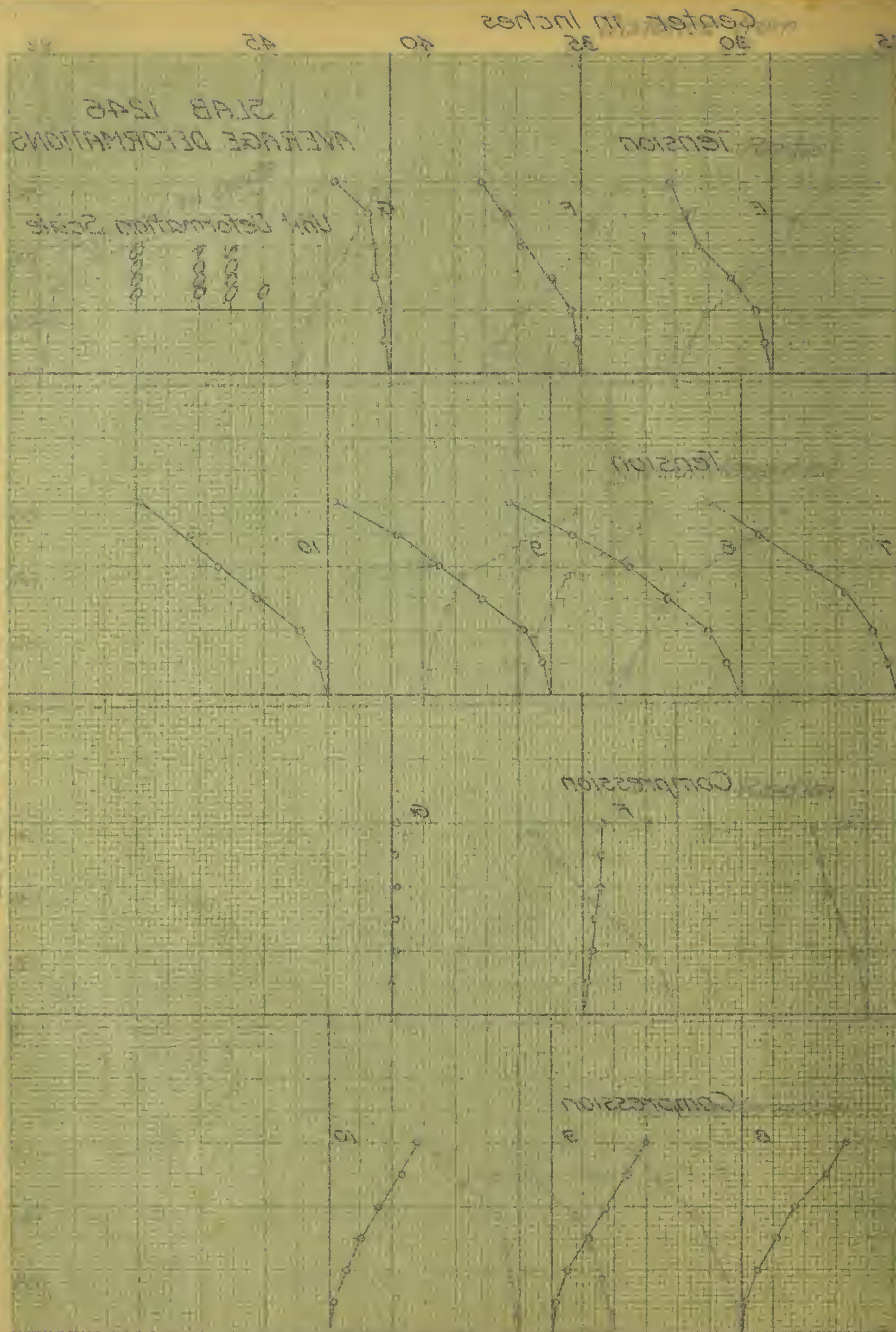


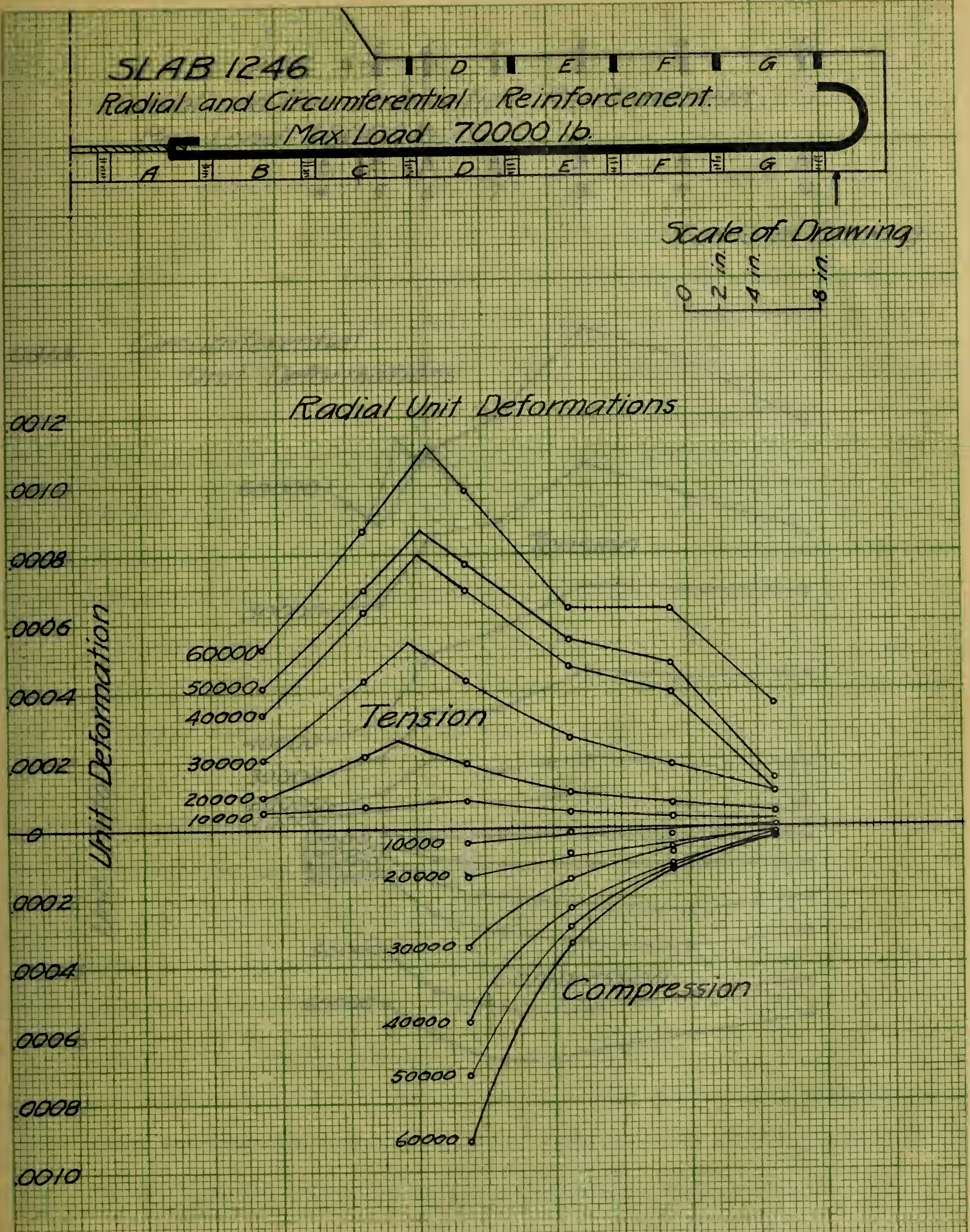
Distance from
10
15
20
25
30
Radial
From rod to plate
A
B
C
D
Circumferential
4
5
6
Load in Thousands of Pounds
60
40
20
0
Radial
D
E
Circumferential
5
6
7

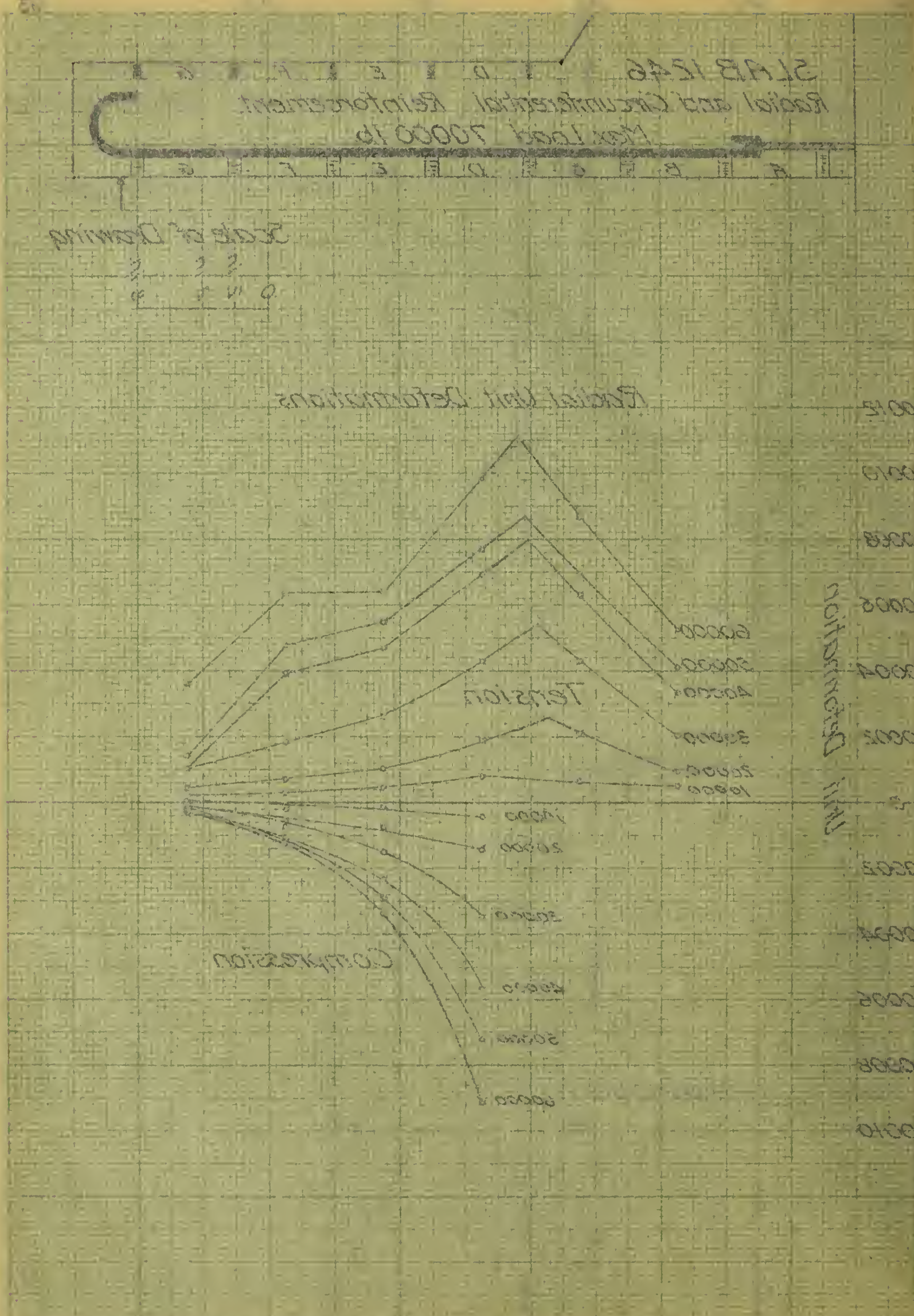


NO 345

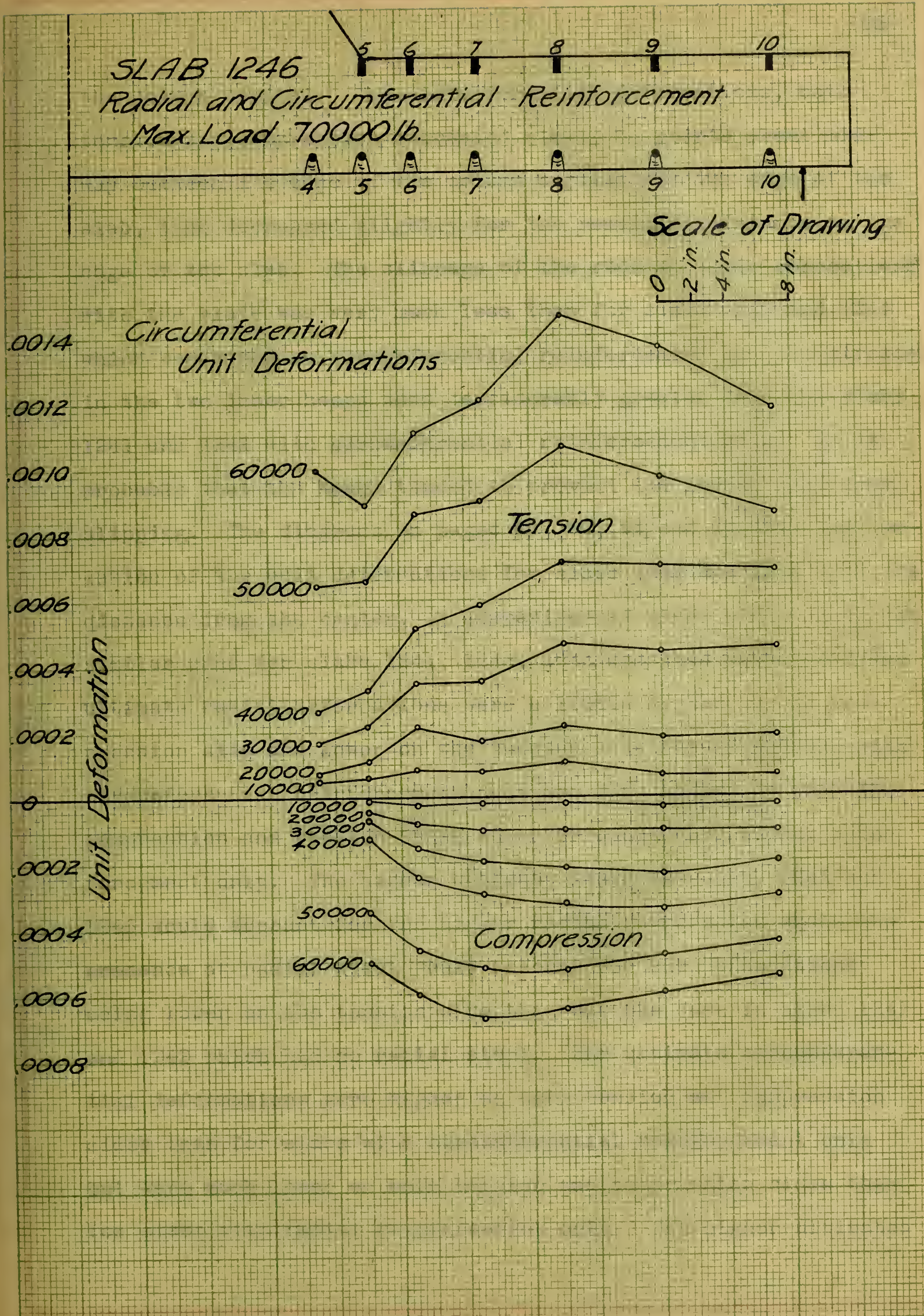
EUGENE DIETZGEN CO. CHICAGO NEW YORK

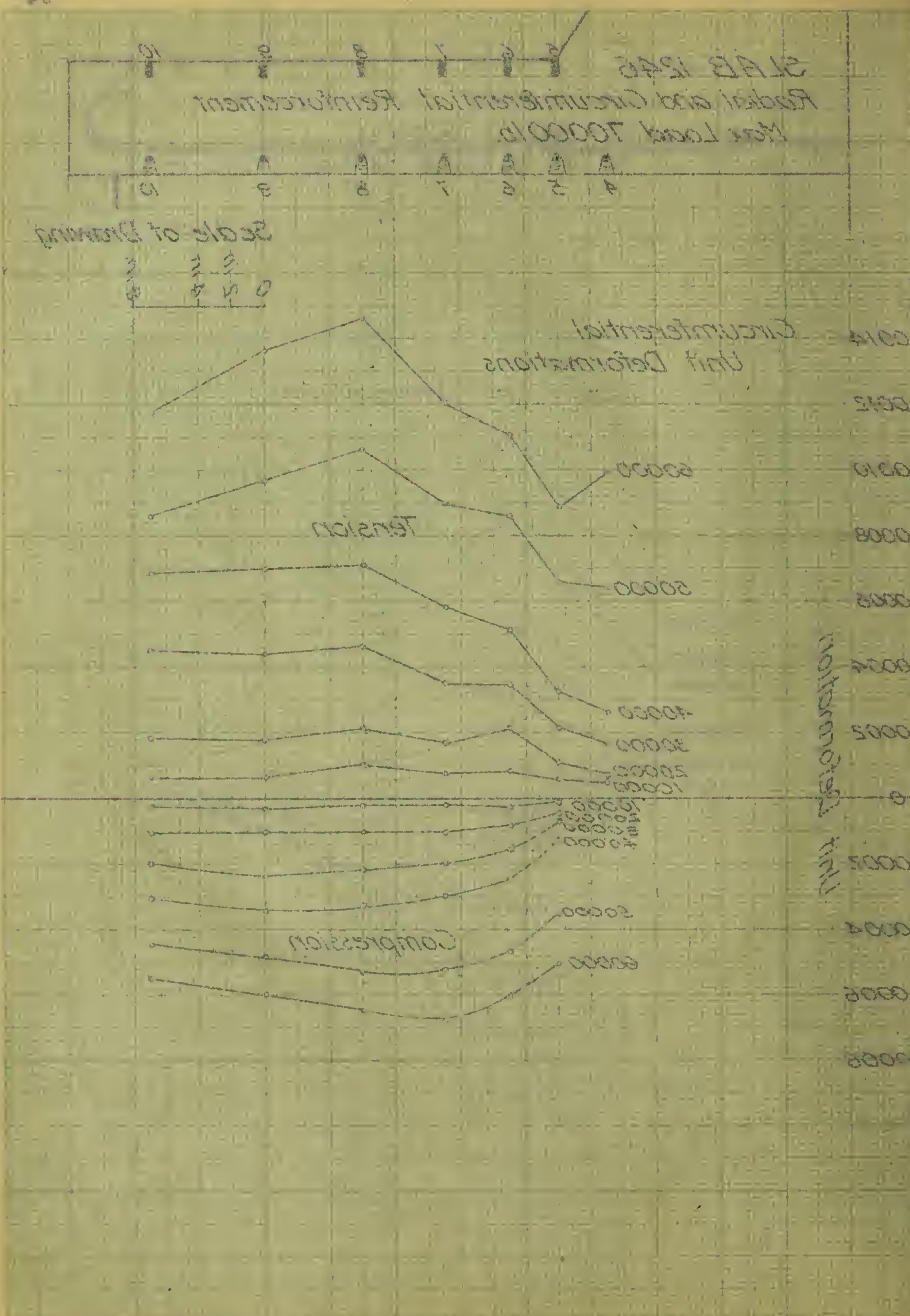

Center in Inches
SLAB 1246
AVERAGE DEFORMATIONS
Unit Deformation Scale
Tension
Tension
Compression
Compression


SLAB 1246
Radial and Circumferential Reinforcement.
Max Load 70000 lb.
A B C D E F G
D E F G
Scale of Drawing
0 2 in. 4 in. 8 in.
Radial Unit Deformations
Unit Deformation
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
60000
50000
40000
30000
20000
10000
Tension
10000
20000
30000
40000
50000
60000
Compression



Slab 1246
Radial and Circumferential Reinforcement
Max Load 70000 lb
Scale of Drawing
Radial Unit Deformations
Unit Deformation
Tension
Compression
60000
50000
40000
30000
20000
10000
10000
20000
30000
40000
50000
60000
.0012
.0010
.0008
.0006
.0004
.0002
.0002
.0004
.0006
.0008
.0010


SLAB 1246
Radial and Circumferential Reinforcement
Max. Load 70000 lb.
5 6 7 8 9 10
4 5 6 7 8 9 10
Scale of Drawing
0 2 in. 4 in. 8 in.
Circumferential
Unit Deformations
Tension
Compression
Unit Deformation
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
60000
50000
40000
30000
20000
10000
10000
20000
30000
40000
50000
60000



SLAB 1245
Radial and Circumferential Reinforcement
Max Load 70000 lb.
Scale of Drawing
Circumferential Unit Deformations
Tension
Compression
Unit Deformation
60000
50000
40000
30000
20000
10000
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0

the column capital. The circumferential deformations, both tension and compression, increased slowly to points about mid-way between the edge of the column capital and the edge of the slab, then decreased slightly for the remaining distance to the edge of the slab. The slippage of the rods at their connections with the plate was very much less than for slabs 1243 and 1244 which contained no circumferential reinforcement and the stresses in the two inner hoops were considerably greater than for slabs 1241 and 1242 with circumferential reinforcement only. It is probable that the hoops tended to prevent the radial rods from slipping. The diagrams on pages 89, 90, 93, and 94 show the variation of the unit deformations for slabs 1245 and 1246 with the distance from the center. A comparison of these curves with the similar ones for slabs 1241, 1242, 1243, and 1244 shows that the ultimate radial deformations were a little higher on the compression side and lower on the tension side than for slabs with circumferential reinforcement only and were higher on both the compression and tension sides than for slabs with radial reinforcement only. The higher ultimate loads for slabs 1245 and 1246 would account for the higher radial compression while the presence of radial steel would account for the deformations being lower on the tension side than was the case in slabs 1241 and 1242 which had no radial steel. The ultimate circumferential deformations were higher on both tension and compression sides than for slabs with circumferential reinforcement only but were much lower on both tension and compression sides than for slabs with radial reinforcement only. The higher ultimates

of slabs 1245 and 1246 would again account for the larger circumferential deformations, both tension and compression, than was the case for slabs 1241 and 1242 with circumferential reinforcement only, while the presence of circumferential steel would account for the lower circumferential deformations, both tension and compression, than for slabs 1243 and 1244 without circumferential reinforcement.

D. SLAB WITH RECTANGULAR FORM OF REINFORCEMENT.

19.. Phenomena of Test.- This slab was the only one which failed entirely from tension in the steel. The usual fine crack under the edge of the column capital appeared at loads of 20 000 and 25 000 lb. As the load increased to 50 000 lb. new cracks appeared from time to time. These were well scattered and opened up but little. At a load of 70 000 lb. the crack under the edge of the column capital opened up. This crack, together with some of the radial ones, were about 1/8 in. wide at the ultimate of 78 000 lb. Figs. 35 and 36 show the location of the cracks and the loads at which they appeared. It is noticeable that there were but few circumferential cracks. This slab showed no special weaknesses and did not punch through as did four of the others.

20. Load-deformation Relations.- The curves for gage lines symmetrical with the center are very uniform. The average deformation curves are shown on pages 100 and 101. Both the radial and circumferential tension curves show the steel to have been stressed beyond the elastic limit. The same phenomena as was observed on the curves for the other slabs regarding the points

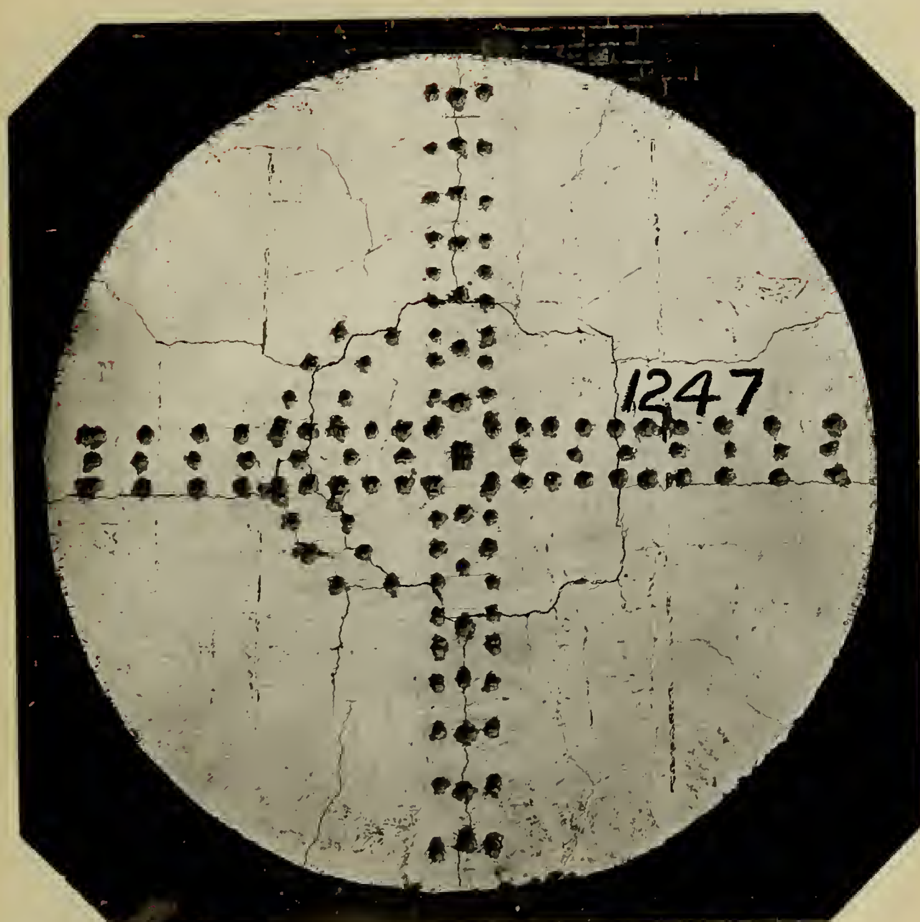


Fig.34. Slab 1247.-View Showing Manner of Failure.

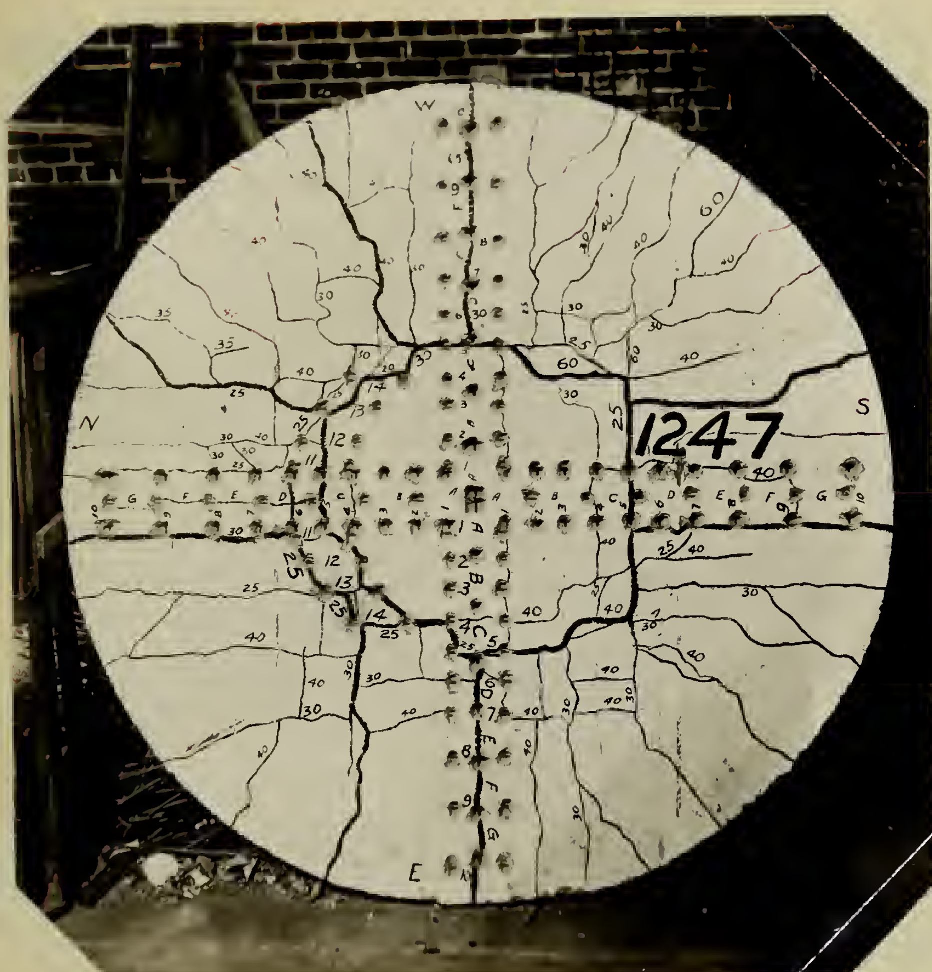


Fig.35. Slab 1247.-View Showing Location of Cracks.

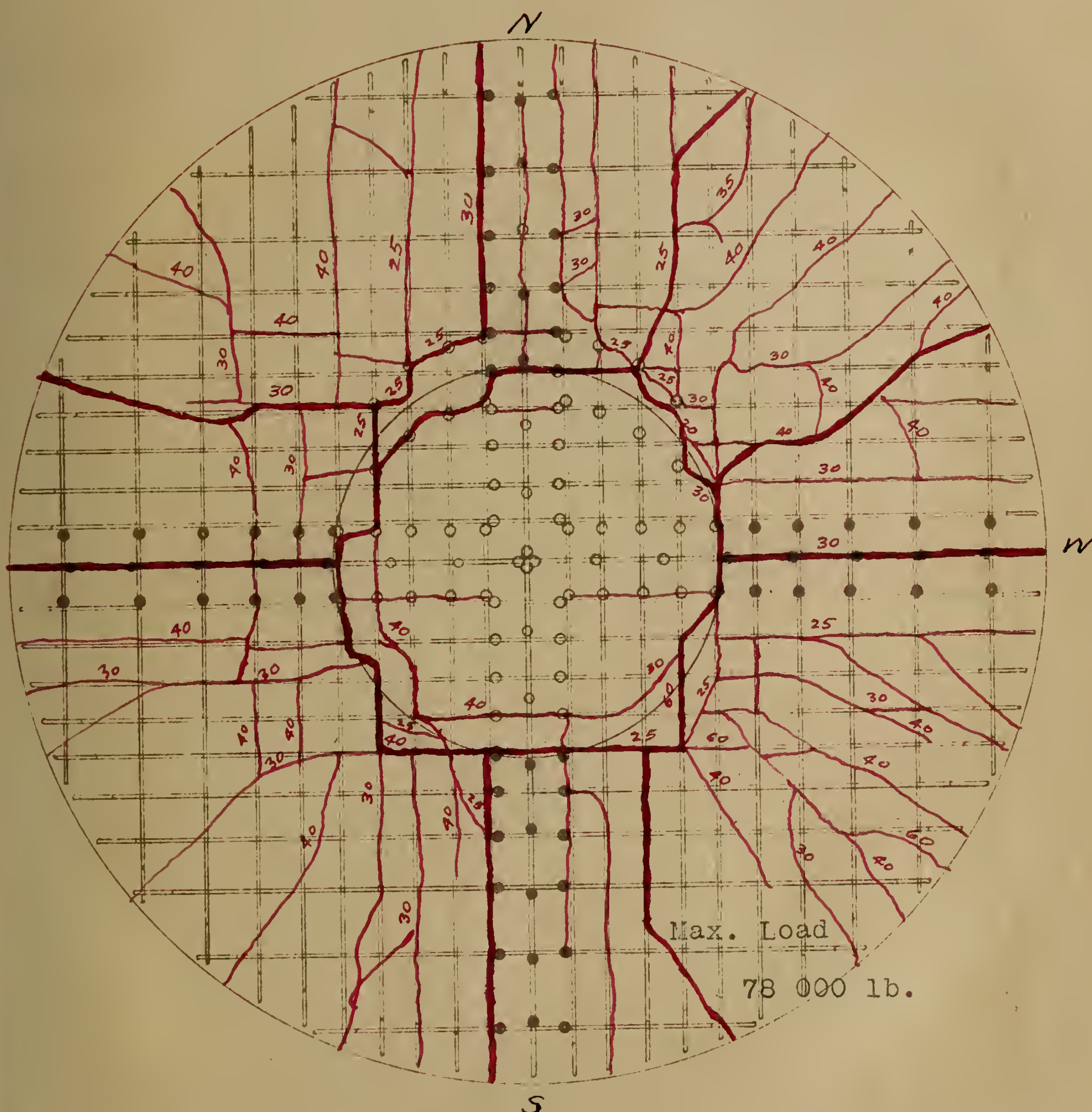
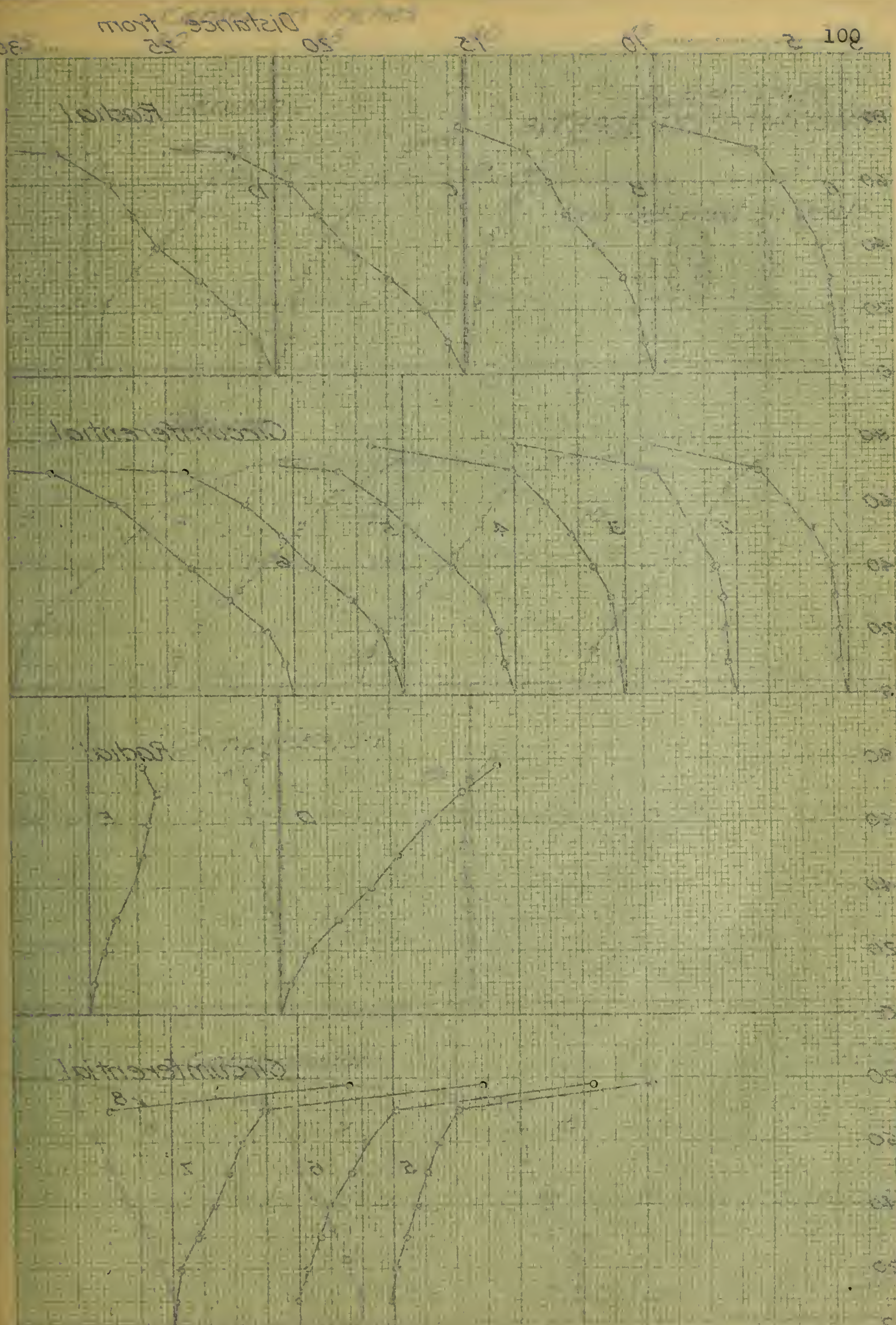
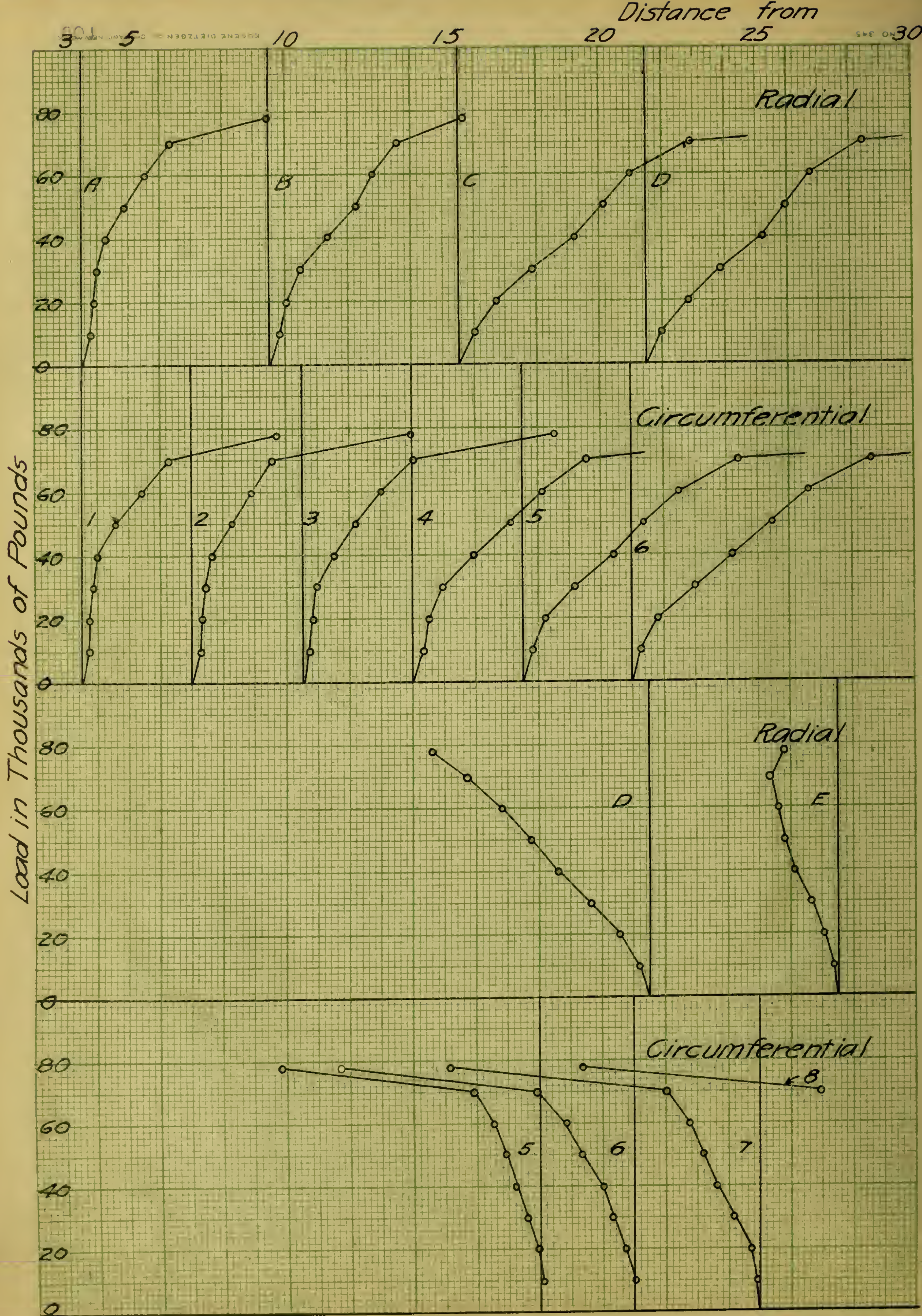
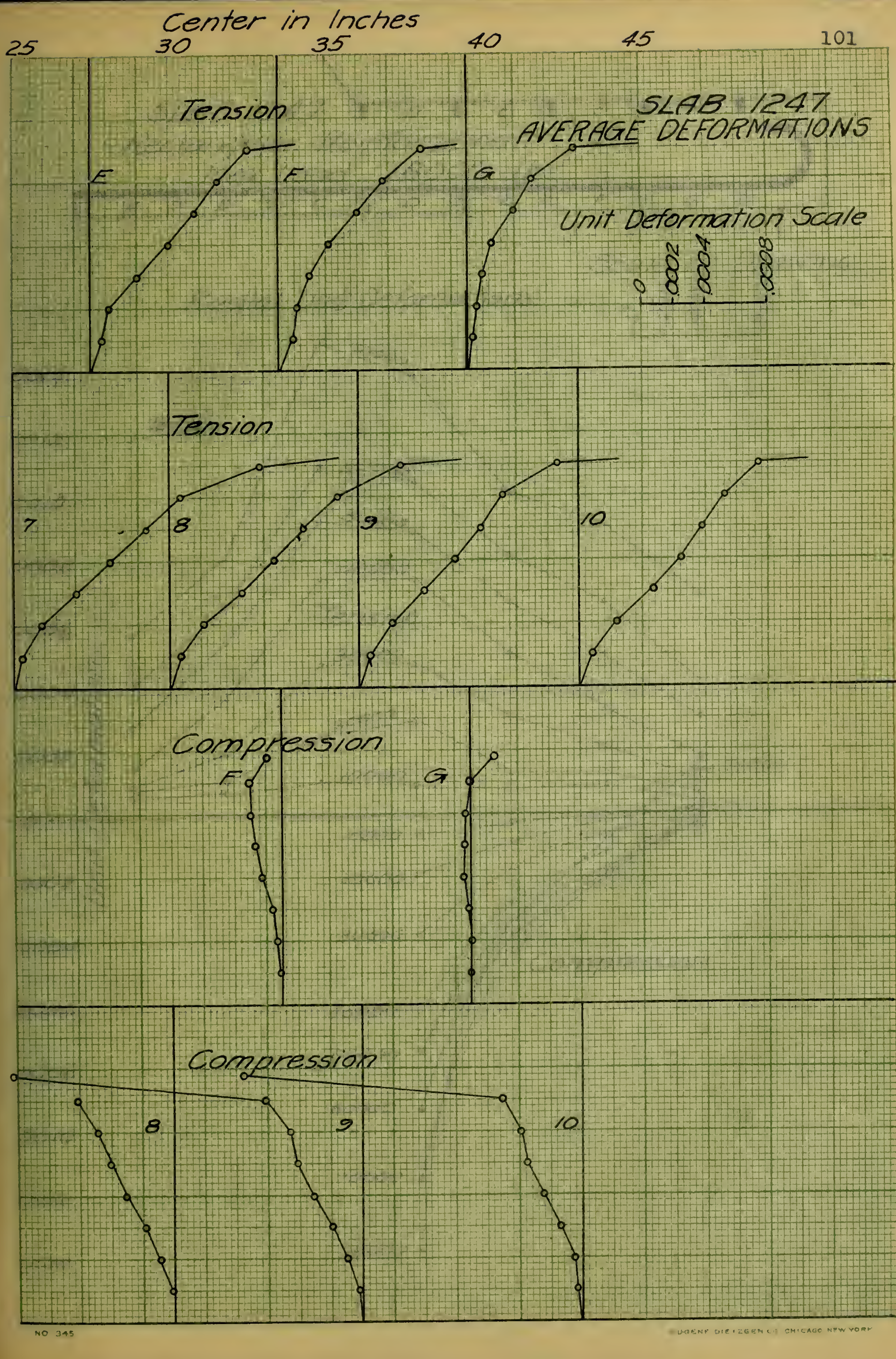


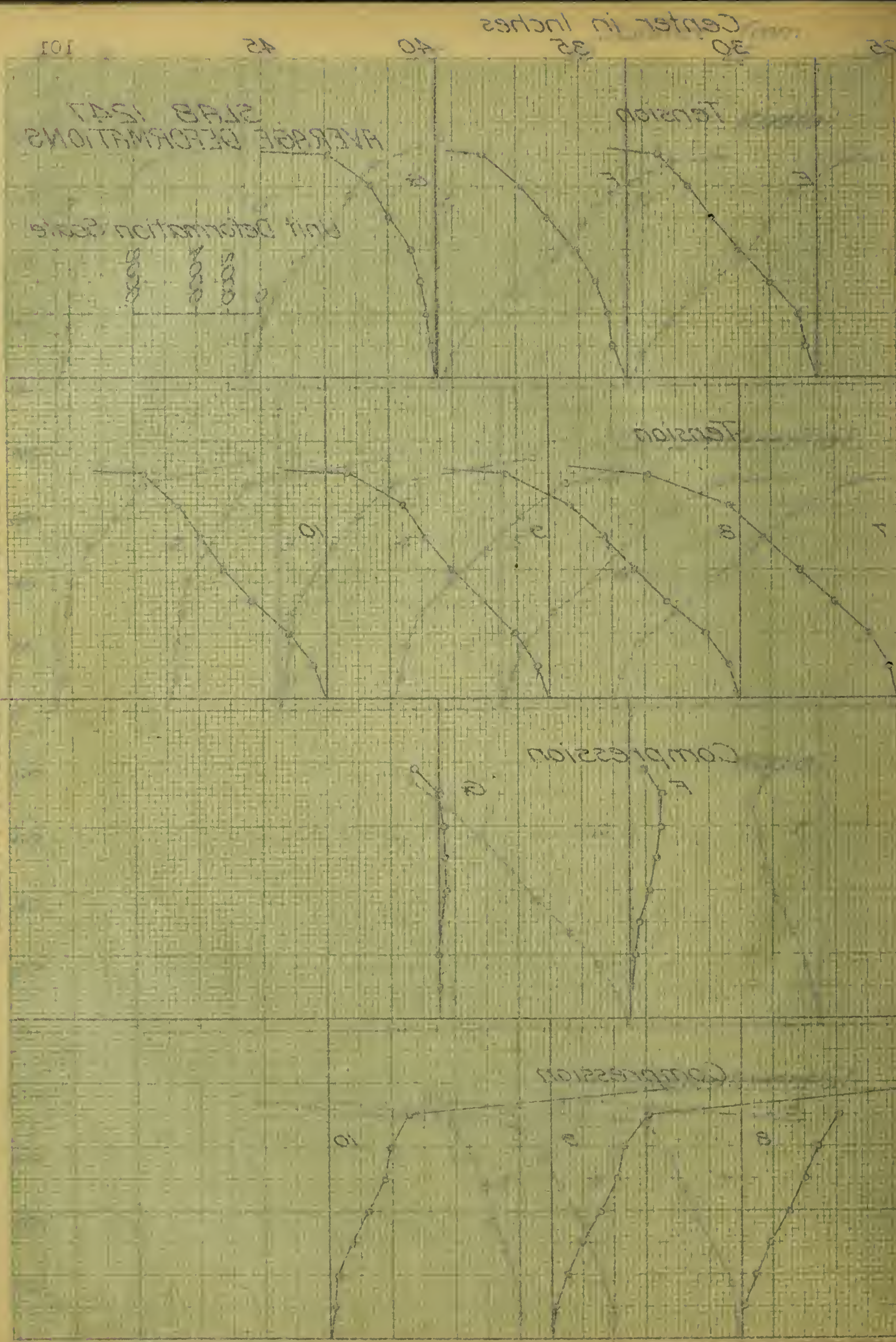
Fig.36. Slab 1247.-Sketch Showing Location of Cracks.

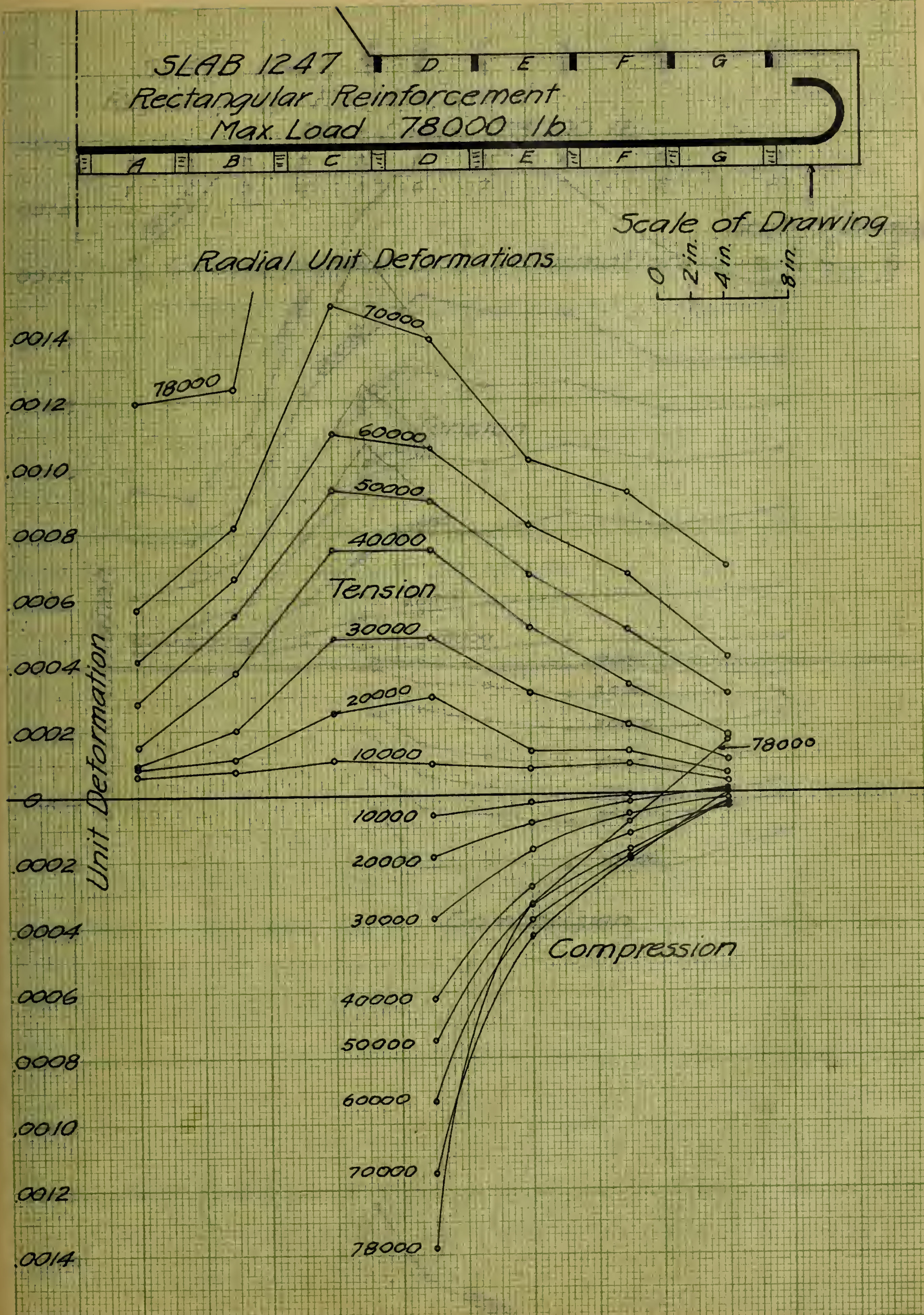


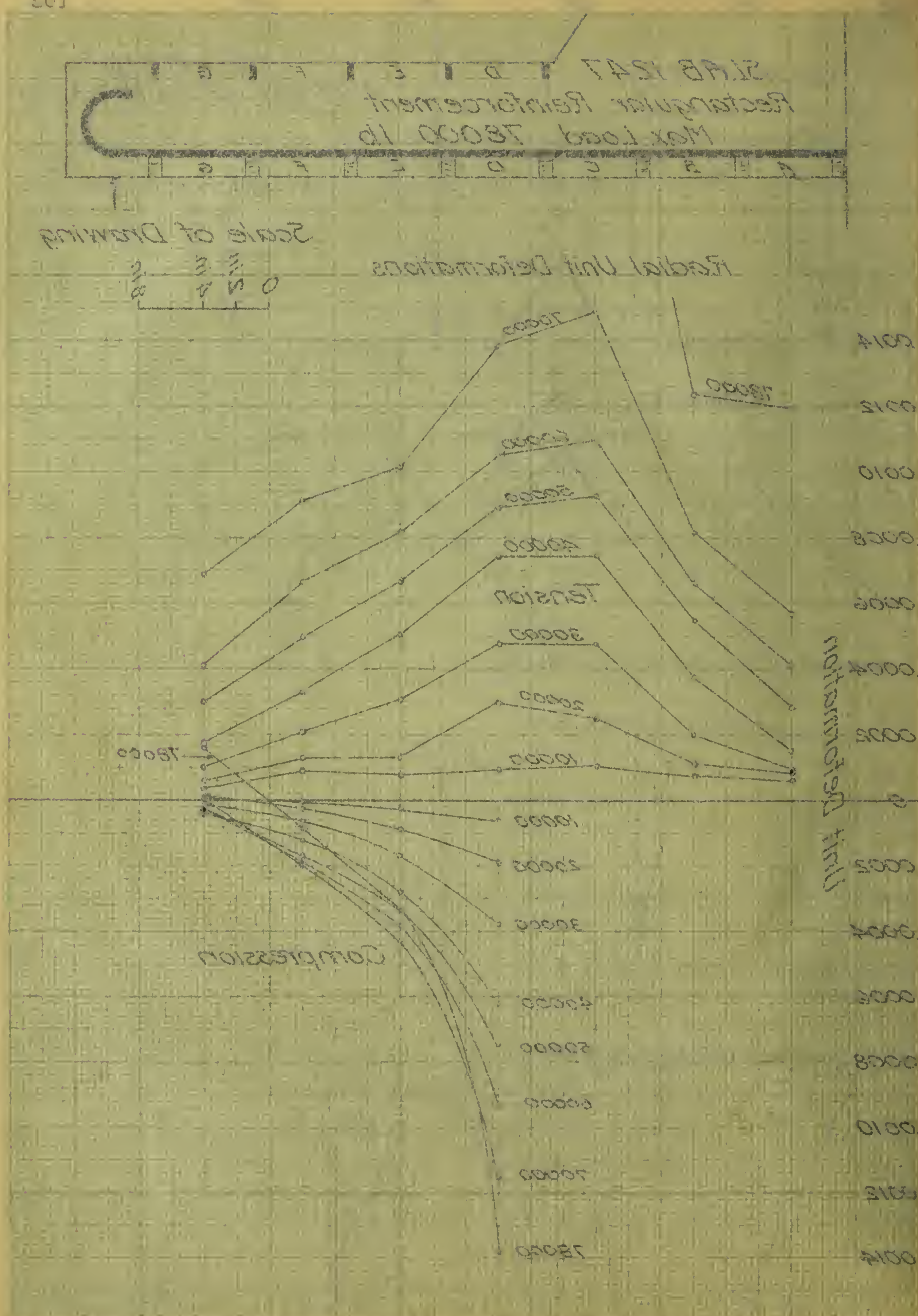


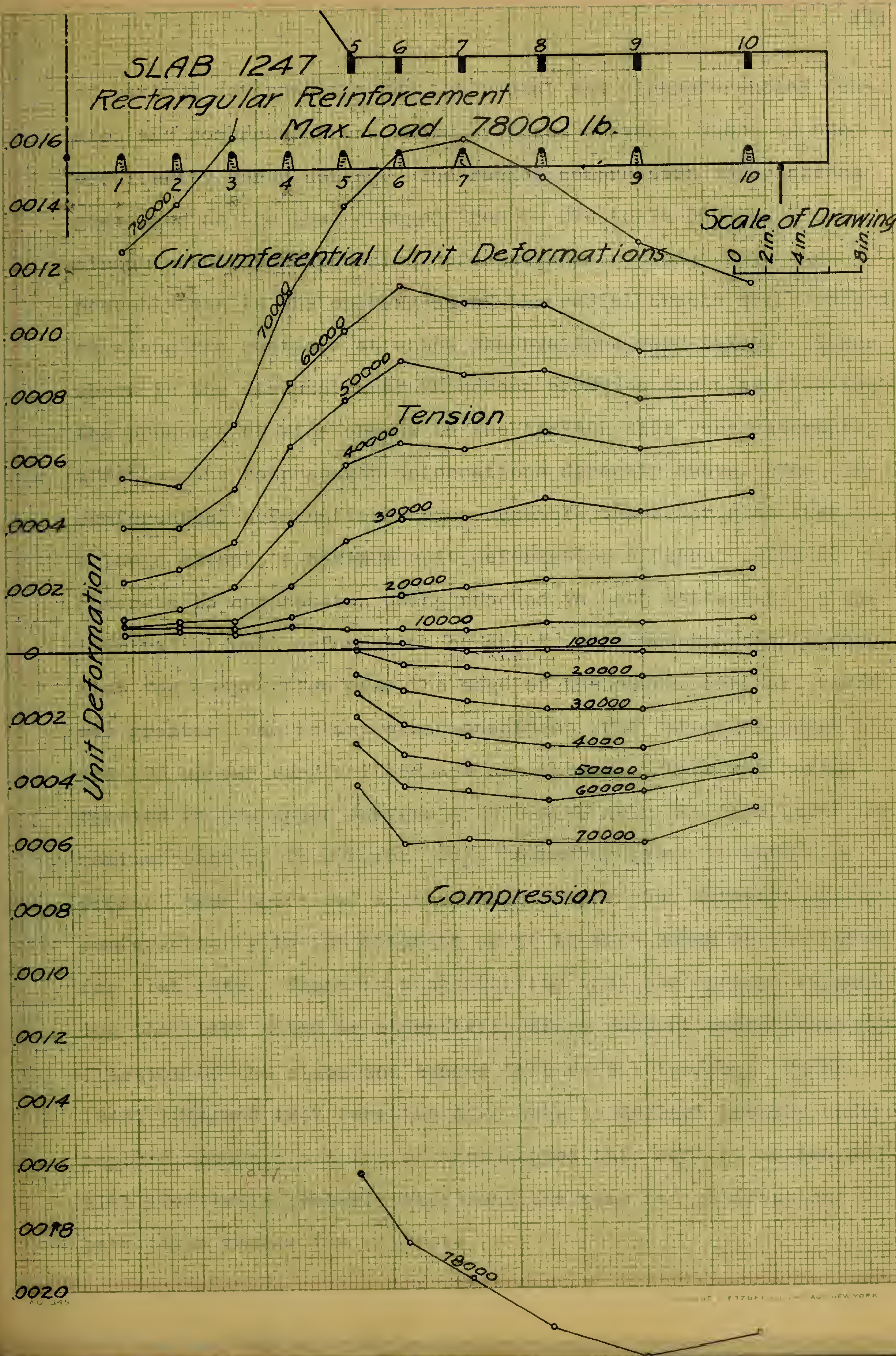
Distance from
3
5
10
15
20
25
30
Radial
Circumferential
Radial
Circumferential
Load in Thousands of Pounds
A
B
C
D
1
2
3
4
5
6
D
E
5
6
7
8
0
20
40
60
80

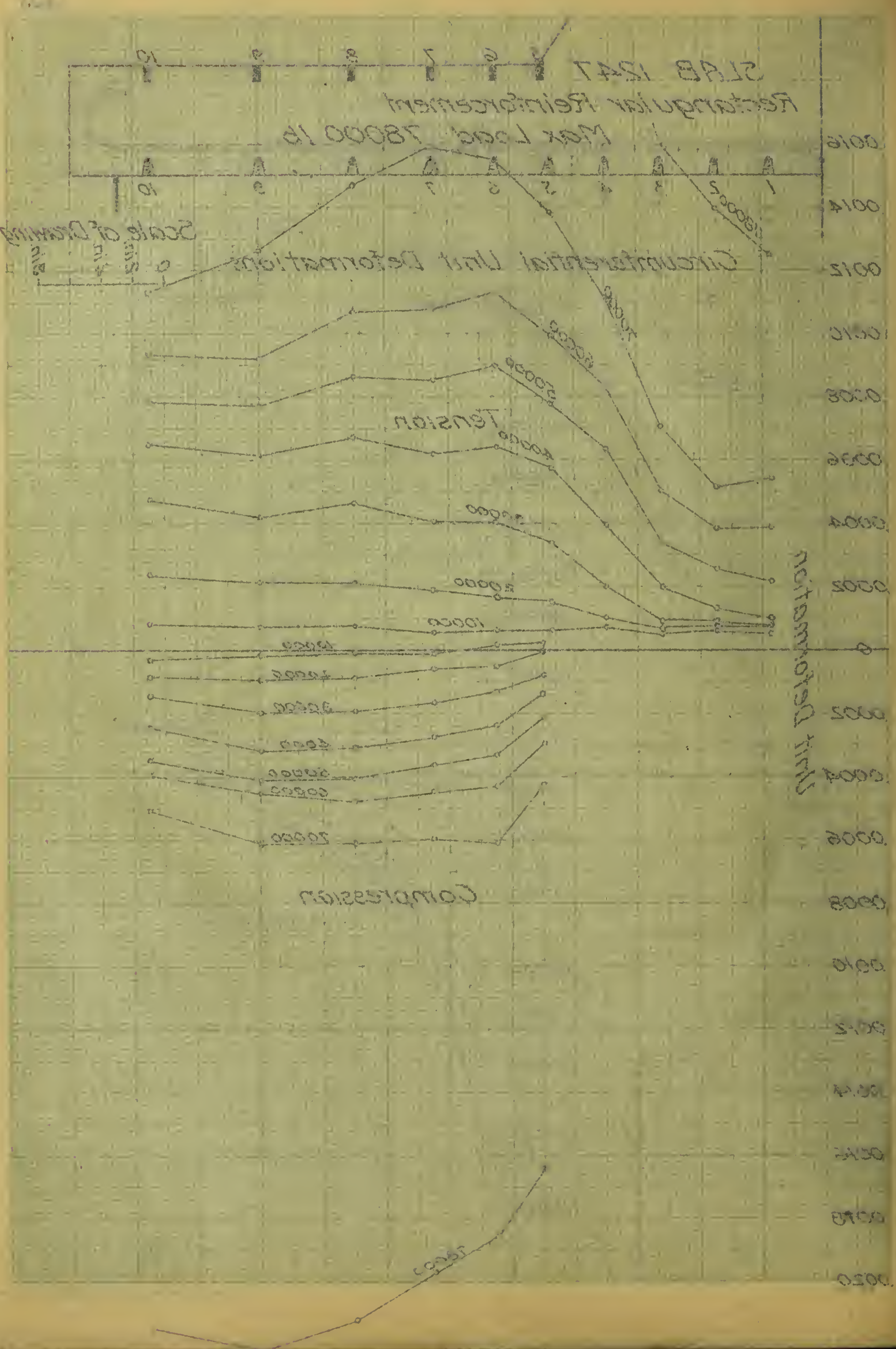

Center in Inches
25
30
35
40
45
SLAB 1247
AVERAGE DEFORMATIONS
Tension
E
F
G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
7
8
9
10
Compression
F
G
Compression
8
9
10
NO 345
EUGENE DIETZGEN CO. CHICAGO NEW YORK


SLAB 1247
AVERAGE DEFORMATIONS
Center in Inches
25
30
35
40
45
Unit Deformation Scale
Tension
Tension
Compression
Compression
Load in Thousands of Pounds


SLAB 1247
Rectangular Reinforcement
Max. Load 78000 lb.
A B C D E F G
Scale of Drawing
0 2 in. 4 in. 8 in.
Radial Unit Deformations
Unit Deformation
Tension
Compression
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
10000
20000
30000
40000
50000
60000
70000
78000


S.H.B. 1247
Rectangular Reinforcement
Max. Load 78000 lb.
Scale of Drawing
Radial Unit Deformations
Tension
Compression
Unit Deformation
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
.0012
.0014
10000
20000
30000
40000
50000
60000
70000
78000


SLAB 1247
Rectangular Reinforcement
Max Load 78000 lb.
Circumferential Unit Deformations
Scale of Drawing
0 2in. 4in. 8in.
Tension
Compression
Unit Deformation
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
.0018
.0020
1 2 3 4 5 6 7 8 9 10
78000
70000
60000
50000
40000
30000
20000
10000
4000



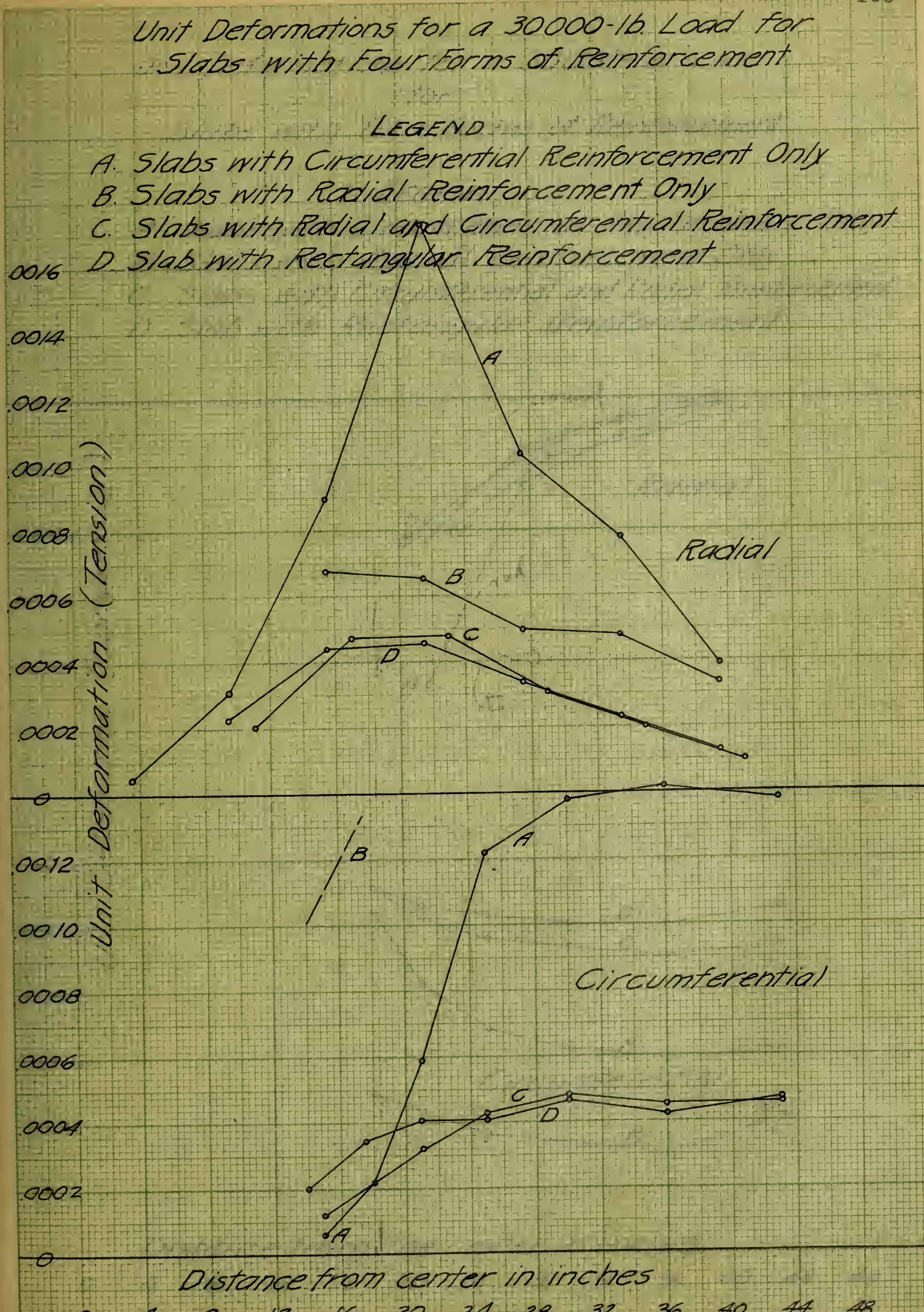
SLAB 1247
Rectangular Reinforcement
Max Load 78000 lb
Circumferential Unit Deformations
Tension
Compression
Unit Deformation
Scale of Drawing

of maximum deformations for the radial and circumferential tension and compression are shown by these curves. There is one peculiarity worth noting. The radial compression deformations grew less as the load changed from 70 000 to 78 000 lb. and the circumferential compression deformations tripled. This was probably due to the opening up of the radial cracks which extended along the sections at which observations were taken. It was shown in the discussion of Phenomena of Tests for slab 1243 that the presence of wide cracks in the tension side very materially affected the compression deformations directly above. The circumferential deformation curves resemble those for slab 1244 to a large extent, a maximum unit deformation of about .0022 in the concrete in compression being reached in both instances. A maximum radial unit deformation of about .0014 was reached in this slab for compression near the edge of the column capital, which was greater than in any other specimen. The curves on pages 102 and 103 appear very uniform and consistent. There was radial tension in the upper surface of the slab near the edge under the maximum load of 78 000 lb. This phenomena seems to have been present when there was a very large compression deformation circumferentially in the concrete as it is also shown in the curves for slab 1244. There is a possibility that the springs supporting the slabs acted as a partially fixed support under great deflection of the slabs and caused this radial tension. Slabs 1243, 1244, and 1247 were the only ones to deflect greatly before rupture occurred and two of them showed this sort of action and slab 1243 would probably have done the same had observations been taken nearer the ultimate.

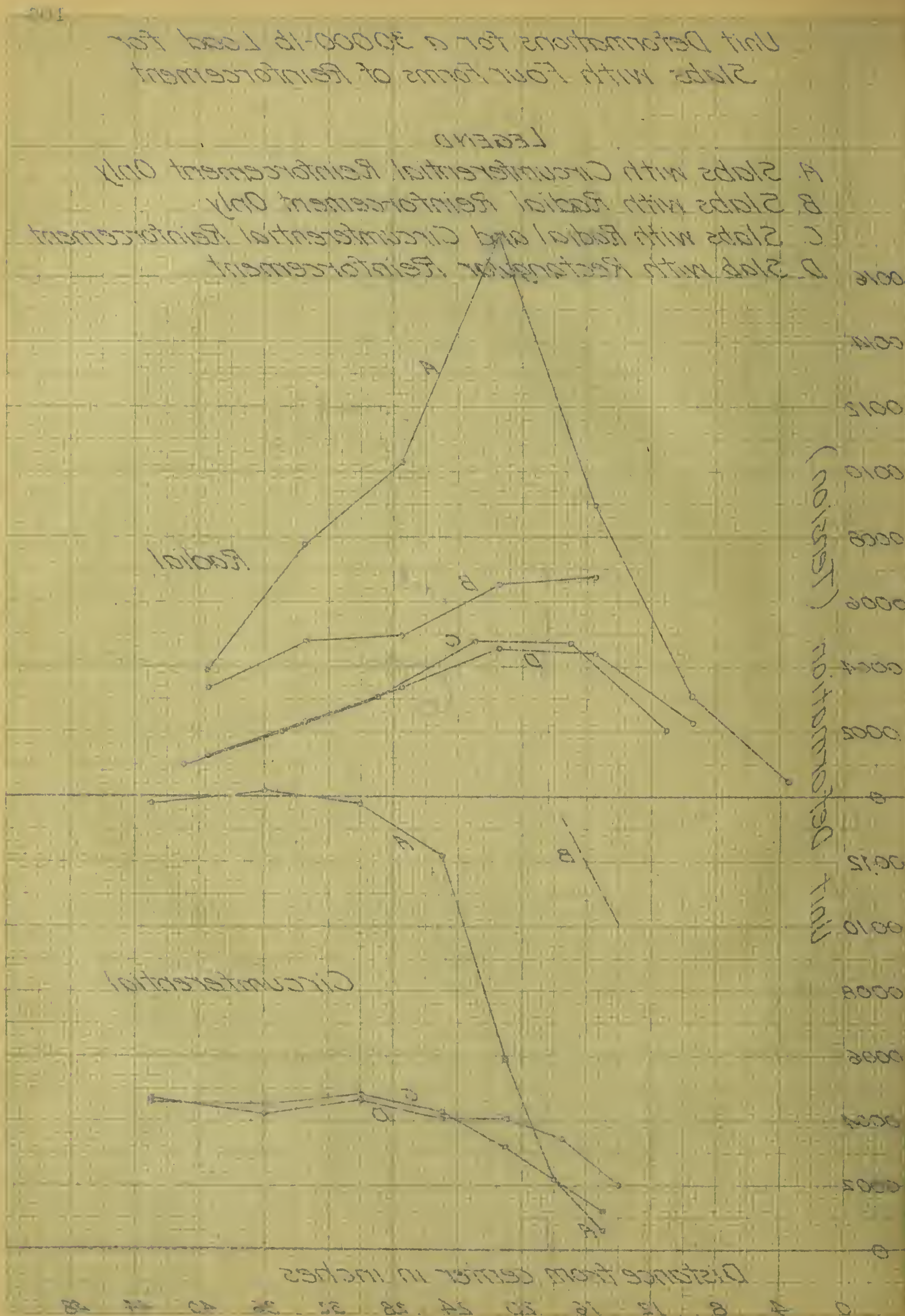
E. SUMMARY.

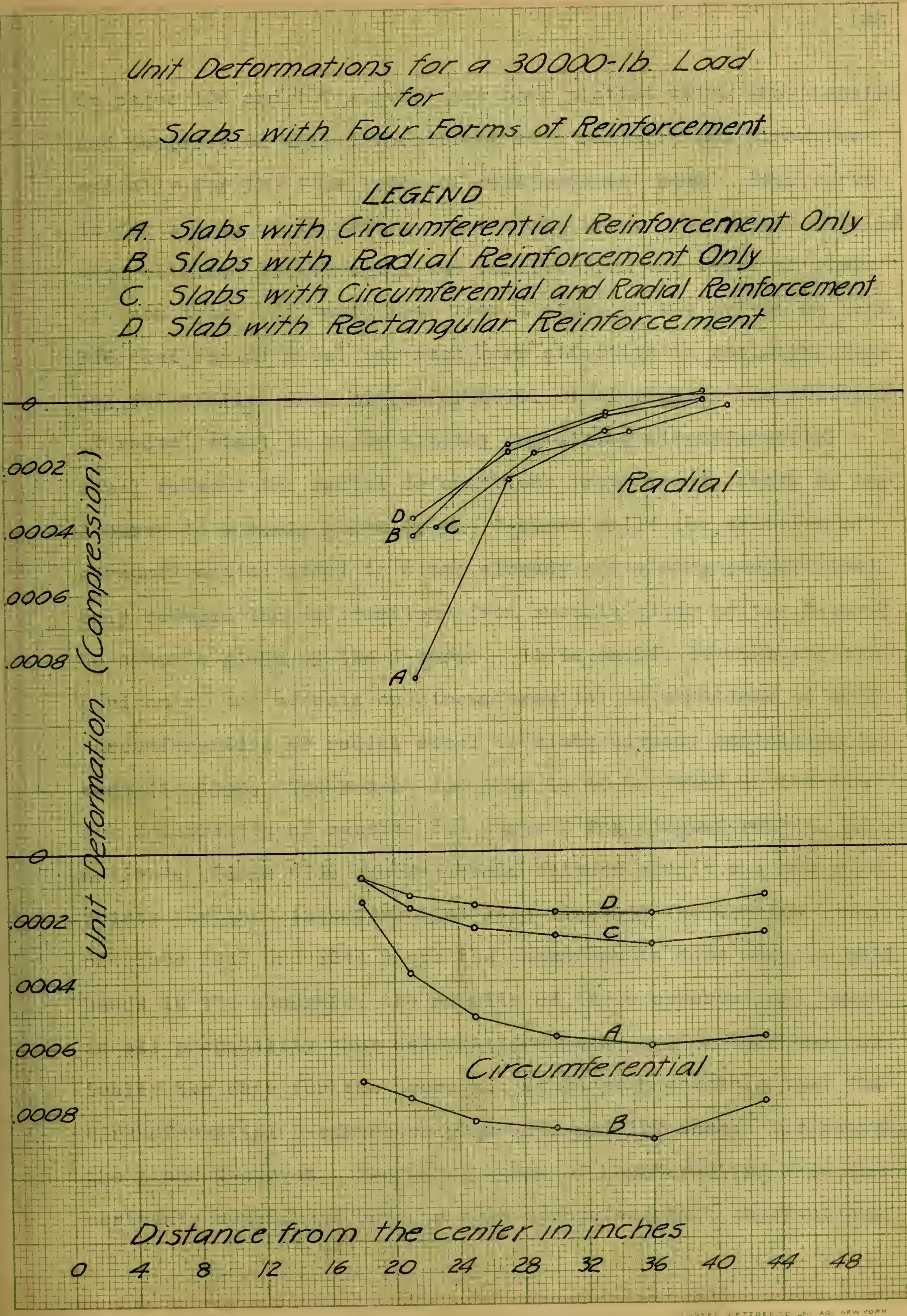
21. Effect of Form of Reinforcement on Manner of Failure.- It is quite clear that the manner of failure of these slabs depended on the form of reinforcement. Slabs 1241 and 1242 with no radial reinforcement punched through, which means that they failed from radial deformation. Slabs 1243 and 1244 with no circumferential reinforcement failed from cracking radially or from circumferential deformation. It is probable that slipping of the rods at their connections with the plates also contributed to the failure of slabs 1243 and 1244 but it is thought that this had little effect on the manner of failure because the radial cracks were very prominent at loads as low as 25 000 lb. when the rods had not slipped to any considerable extent. Slabs 1245 and 1246 punched through in a manner similar to the slabs with circumferential reinforcement only but at loads about double those for the latter. The multitude of cracks remained small up to the ultimate loads. It was noticeable that for slabs which punched through there was comparatively little deflection when failure occurred while for slabs which failed by radial cracks and tension in the steel there was nearly as much as 2 inches. It would seem that circumferential hoops used as reinforcement ought to add materially to the stiffness of the structure but if used alone would be subject to sudden failure. Slab 1247 with the rectangular form of reinforcement sustained the heaviest load of any of the specimens and failed by tension in the steel.

22. Effect of Form of Reinforcement on Stresses.- The form of reinforcement seems to have had considerable effect on the tension and compression stresses as indicated by the deformations.



Unit Deformations for a 30000-lb. Load for
Slabs with Four Forms of Reinforcement
LEGEND
A. Slabs with Circumferential Reinforcement Only
B. Slabs with Radial Reinforcement Only
C. Slabs with Radial and Circumferential Reinforcement
D. Slab with Rectangular Reinforcement
Radial
Circumferential
Unit Deformation (Tension)
Distance from center in inches
.0016
.0014
.0012
.0010
.0008
.0006
.0004
.0002
0
A
B
C
D
0 4 8 12 16 20 24 28 32 36 40 44 48

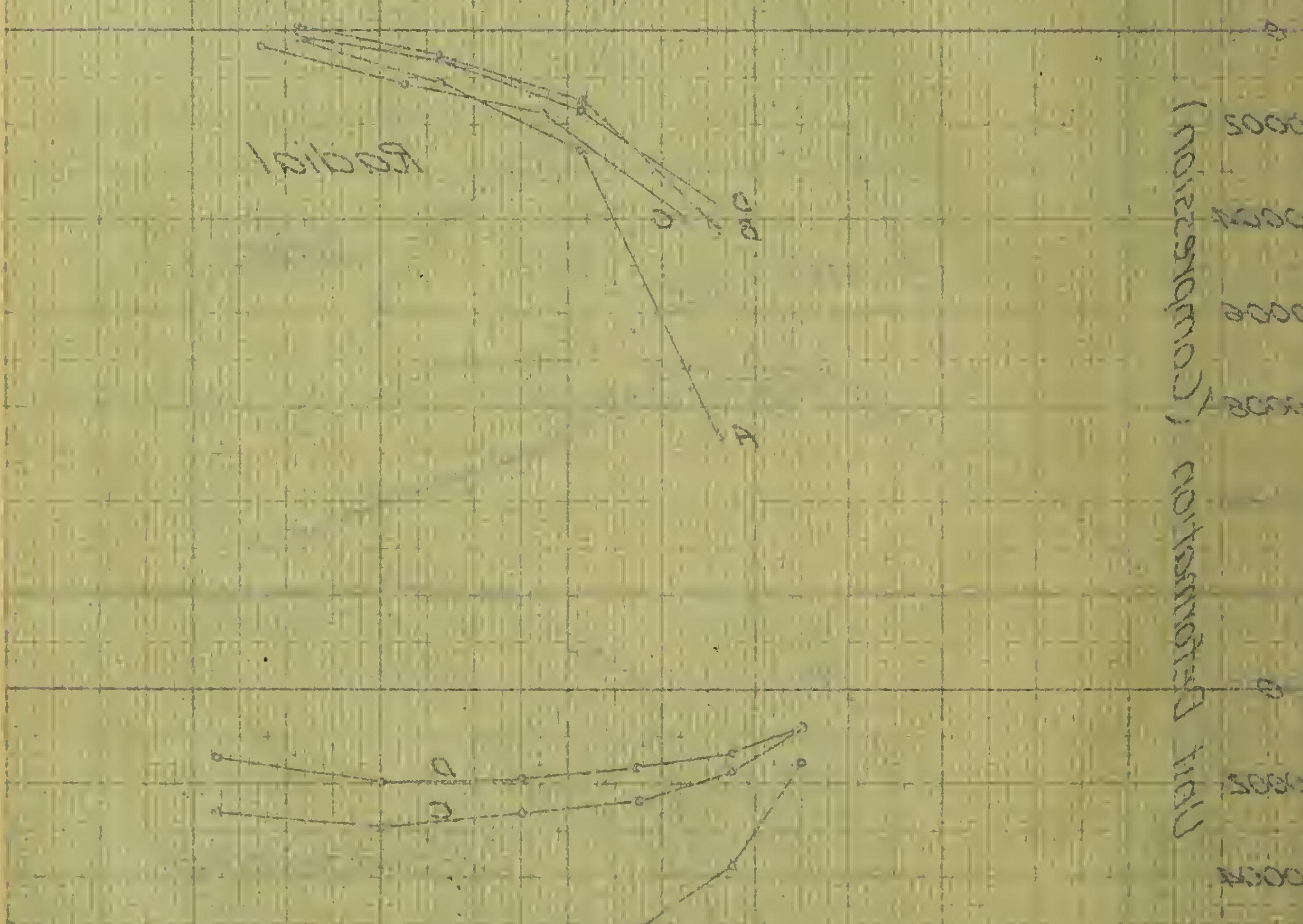

Unit Deformations for a 30000-lb Load for
Slabs with Four Forms of Reinforcement
Legend
A. Slabs with Circumferential Reinforcement Only
B. Slabs with Radial Reinforcement Only
C. Slabs with Radial and Circumferential Reinforcement
D. Slab with Rectangular Reinforcement
Radial
Circumferential
Unit Deformation (Tension)
Distance from center in inches



Unit Deformations for a 30000-lb. Load
for
Slabs with Four Forms of Reinforcement
LEGEND
A. Slabs with Circumferential Reinforcement Only
B. Slabs with Radial Reinforcement Only
C. Slabs with Circumferential and Radial Reinforcement
D. Slab with Rectangular Reinforcement
Radial
Circumferential
Unit Deformation (Compression)
0
.0002
.0004
.0006
.0008
A
B
C
D
Distance from the center in inches
0 4 8 12 16 20 24 28 32 36 40 44 48

Unit Deformations for a 30000-lb. Load
for
Slabs with Four Forms of Reinforcement

LEGEND
A. Slabs with Circumferential Reinforcement Only
B. Slabs with Radial Reinforcement Only
C. Slabs with Circumferential and Radial Reinforcement
D. Slab with Rectangular Reinforcement



On pages 106 and 107 curves have been plotted which show tension and compression unit deformations both radially and circumferentially for the four types of reinforcement used. Each curve is for a load of 30 000 lb. on the specimen. The values plotted were obtained by averaging the results from the tests of slabs of each type. It would seem from a study of the curves on page 106 that radial steel was much more effective in resisting radial deformation than circumferential steel because the addition of radial steel to slabs already containing circumferential steel reduced the radial deformations from amounts shown by the A-curve to amounts shown by the C-curve while the addition of circumferential steel to slabs already containing radial steel only reduced the deformations from amounts given by the B-curve to amounts given by the C-curve. It is unsafe to make any comparison of the effects on circumferential deformations of adding circumferential or radial steel to slabs already containing the opposite type. The reason for this is to be found in the doubtful reliability of results for curve B for circumferential deformations. Since wide cracks formed between nearly all the gage points for the circumferential gage lines on the tension sides of slabs 1243 and 1244 where the measurements were made on nail heads in the concrete, the results of these observations would in all probability show deformations much greater than was actually the case for the average. It is even possible that the circumferential B-curves on pages 106 and 107 should lie between the A and C-curves. The only method of counteracting this uncertainty would have been to take circumferential observations

in series entirely around the specimens. The amount of work involved prohibited this scheme. In general it appears quite safe to say that the addition of radial steel was much more effective than the addition of circumferential steel. The truth of this statement is also borne out by a comparison of the ultimate loads for the addition of radial steel raised the ultimate from about 34 000 lb. to about 66 000 lb. while the addition of circumferential steel only increased the ultimate from 50 000 lb. to about 66 000 lb. From the closeness of the positions of curves C and D it would seem that the action in the slab with the rectangular form of reinforcement was practically the same as that in slabs of type C with circumferential and radial reinforcement and that the rods placed in two layers at right angles acted as both radial and circumferential reinforcement. The amount of steel outside the column capital was practically the same in slab 1247 of type D as that in slabs 1245 and 1246 of type C as shown by Table 5, page 17.

23. Comparison of Circumferential and Radial Deformations.- A comparison of the curves on the previous pages fail to show any very marked relations between the radial and circumferential deformations for the different specimens. However, a few general relations may be noted. In slabs 1241 and 1242 with circumferential reinforcement only the maximum radial deformations exceeded the maximum circumferential deformations. In slabs 1243 and 1244 with radial reinforcement only it appears that the maximum circumferential deformations exceeded the radial but no certain conclusions can be drawn concerning this because of the

effect the large radial cracks had on the circumferential deformations. In slabs 1245 and 1246 with both radial and circumferential reinforcement the maximum circumferential deformations slightly exceeded the radial in tension and the radial exceeded the circumferential in compression. In slab 1247 with the rectangular form of reinforcement the maximum circumferential tension deformations were about equal to the radial while in compression the opposite was true until the slab was about to rupture. From the foregoing relations noted it is difficult to draw definite conclusions but it is interesting to note that in five of the slabs the maximum radial deformations exceeded the circumferential in compression while in four of the five slabs the opposite was true in tension. In no case did the maximum radial deformations come at the same section as the maximum circumferential deformations.

24. Suggestions for Design of Future Test Specimens.- Should it be deemed advisable to make further tests on specimens of cantilever flat slabs similar to those described in this thesis two suggestions, drawn from a study of the results shown herein, are offered. First, the radial rods should be securely welded to the plate to prevent slipping of the rods. Second, the spacing of the hoops should not increase with the distance from the center. This form of reinforcement would probably be much more efficient if the spacing decreased out to a section about mid-way between the edge of the column capital and the edge of the slab, and then either remained constant or increased slightly with the remaining distance to the edge of the slab.

F. THEORY AND ANALYSIS.

25. Development of Formulas.- For shapes made of homogeneous material, as steel, such properties as the moment of inertia, modulus of elasticity, and position of the neutral axis can be quite definitely determined. As a result flexure theories applied to simple units of homogeneous material such as steel beams can be depended upon to a considerable degree of certainty. Where there is curvature in more than one direction, as in the case of flat plates, the treatment becomes much more involved even when the properties of the material are quite definitely known. For flat slabs of reinforced concrete, where these properties are difficult to determine and also vary with the section and the strain to which the fibres are subjected, the difficulties of working out a satisfactory solution to the problem are such as to make the results only approximate at best. The following analysis is therefor offered with the knowledge that it is probably open to serious criticism. A theoretical treatment on such a complicated subject as flexure in reinforced concrete flat slabs which could be worked out and presented in this thesis must necessarily be far from exhaustive.

In the treatment which follows the following notation will be used:

P = total load on slab.

R = radius of slab.

R_o = radius of column capital.

x = any distance from the center measured along a radius.

M = bending moment (considered as acting radially).

M_R = radial resisting moment.

M_c = circumferential resisting moment.

S = unit stress in extreme fibre.

c_R = distance from neutral axis to extreme fibre for radial resisting moment section.

c_c = distance from neutral axis to extreme fibre for circumferential resisting moment section.

$\mathcal{E}_R$ = unit radial deformation.

$\mathcal{E}_c$ = unit circumferential deformation.

E_R = modulus of elasticity for material at radial resisting moment section.

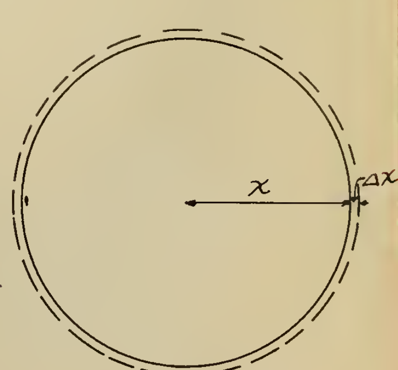
E_c = modulus of elasticity for material at circumferential resisting moment section.

I_R = moment of inertia for radial resisting moment section.

I_c = moment of inertia for circumferential resisting moment section.

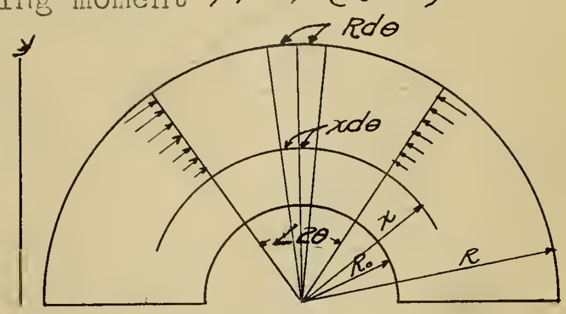
n, k, j, b, d, A, are terms in common use in discussions of reinforced concrete members.

The following fundamental relation exists between the radial and circumferential unit deformations. In the figure shown the average unit deformation radially $= \frac{\Delta x}{x}$. The original circumference $= 2\pi x$, and the circumference after deformation of the radius $= 2\pi x + 2\pi \Delta x$. The total circumferential deformation $= 2\pi\Delta x$, and the unit circumferential deformation $= \frac{2\pi\Delta x}{2\pi x} = \frac{\Delta x}{x}$. It is thus shown that the circumferential unit deformation along a section of radius x is equal to the



average radial unit deformation or that $\varepsilon_c = \frac{\Sigma[\varepsilon_R]_0^{x_1}}{x_1}$. (1)

The following treatment of bending and resisting moments is based on the theory that in slabs of this form there is but one bending moment which acts radially at all times, while the resisting moment consists of two parts, radial and circumferential. This seems to be a different view from that taken in Turneaure and Maurer's Principles of reinforced Concrete Construction where both radial and circumferential bending moments are mentioned. However, it is difficult to conceive of any but a radial bending moment but seems evident that circumferential stresses should help out the radial in resisting flexure. In amount the radial bending moment is equal to the load multiplied by the distance of the section from the line of application of the load. The total radial bending moment $M = P(R-x)$.



To get the relation between radial bending moment and radial and circumferential resisting moments in terms which are known or can be computed consider a section of a slab as shown in the figure. It is first assumed that there is a state of fixidity inside the edge of the column capital, or that there is no radial deformation from $x = 0$ to $x = R_0$. Then $\frac{\Sigma[\varepsilon_R]_{R_0}^{x_1}}{x_1} = \frac{\Sigma[\varepsilon_R]_0^{x_1}}{x_1}$. The effect of the presence of radial deformation in this area will be taken up later and corrections made.

If P = load on slab applied at the perimeter then $\frac{P}{2\pi R}$ = load on unit distance of perimeter.

Load on $R d\theta = \frac{P}{2\pi R} R d\theta = \frac{P d\theta}{2\pi}$.

Bending moment caused by this load $= \frac{P}{2\pi}(R-x)d\theta$.

Component of bending moment parallel to $y = \frac{P}{2\pi}(R-x)\cos\theta d\theta$.

Total radial resisting moment $= \frac{S_R I_R}{C_R}$

Radial resisting moment on section $x d\theta = \frac{S I_R}{2\pi x C_R} x\, d\theta = \frac{S I_R}{2\pi C_R} d\theta$.

Component of radial resisting moment parallel to $y = \frac{S I_R}{2\pi C_R}\cos\theta d\theta$.

Component of circumferential resisting moment parallel to y and subtending an angle $2\theta = \frac{S_c I_c}{C_c}\sin\theta$, where the section considered is along twice the distance from x to R.

Equating bending moment to sum of resisting moments.-

$$2\int_0^\theta \frac{P}{2\pi}(R-x)\cos\theta d\theta = 2\int_0^\theta \frac{S_R I_R}{2\pi C_R}\cos\theta d\theta + \frac{S_c I_c}{C_c}\sin\theta$$

$$\frac{P}{\pi}(R-x)\sin\theta = \frac{S_R I_R}{\pi C_R}\sin\theta + \frac{S_c I_c}{C_c}\sin\theta$$

$$P(R-x) = \frac{S_R I_R}{C_R} + \pi\frac{S_c I_c}{C_c}$$

$$\frac{S_R I_R}{C_R} = P(R-x) - \pi\frac{S_c I_c}{C_c} \qquad (2)$$

$$M_R = M - M_c$$

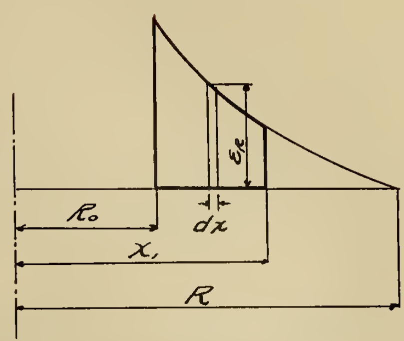
This radial resisting moment is considered as causing the radial deformations.

Since $S = \varepsilon E$ the equation above may be written,-

$$\frac{E_R I_R}{C_R}\varepsilon_R = P(R-x) - \frac{\pi E_c I_c}{C_c}\varepsilon_c$$

$$\varepsilon_R = \frac{P C_R}{E_R I_R}(R-x) - \frac{\pi C_R E_c I_c}{C_c E_R I_R}\varepsilon_c \qquad (3)$$

It has been previously shown that the circumferential unit deformation at any section distant x_1 from the center is equal to the average radial unit deformation over the distance x_1 from the center. The figure shows how this applies. If the area below the curve



$$\varepsilon_R = \frac{p c_R}{E_R I_R}(R-x) - \frac{\pi c_R E_c I_c}{c_c E_R I_R}$$

between the limits $x = R_o$ and $x = x_1$ be obtained and divided by x_1 the result is the average radial unit deformation over the distance x_1 from the center and is equal to ε_c

It follows that

$$\varepsilon_c = \frac{\Sigma\left[\varepsilon_R\right]_{R_o}^{x_1}}{x_1} = \frac{1}{x_1}\int_{R_o}^{x_1}\left[\frac{p c_R}{E_R I_R}(R-x) - \frac{\pi c_R E_c I_c}{c_c E_R I_R}\varepsilon_c\right]dx \qquad (4)$$

It is known that c, E, and I vary with the distance x but because the variation for c and E cannot be determined and does not affect the results as much as the variation for I, c and E will be treated as constants. Values for I_R and I_c will be determined in terms of functions of x and inserted in equation (4)

For a reinforced concrete section $I = \frac{1}{3}b(kd)^3 + nA(1-k)^2d^2$

$$A = pbd \qquad k = \sqrt{2pn + p^2n^2} - pn \qquad p = \frac{k^2}{2n(1-k)}$$

$$A = \frac{k^2}{2n(1-k)}bd$$

$$I = \frac{1}{3}k^3bd^3 + nk^2\frac{(1-k)^2}{2n(1-k)} = \frac{1}{3}k^3bd^3 + \frac{1}{2}k^2bd^3 - \frac{1}{2}k^3bd^3$$

$$= \frac{1}{2}bk^2d^3\left(1 - \frac{k}{3}\right) = \frac{1}{2}bk^2jd^3$$

For determining I_R, $b = 2\pi x$ and for determining I_c, $b = 2(R-x)$

$$I_R = \pi k_R^2 j_R d^3 x \qquad I_c = k_c^2 j_c d^3 (R-x)$$

As the variation of k and j is probably small these terms are considered constant in the derivation which follows.

Substituting the values for I_R and I_c in equation (4)

$$\varepsilon_c = \frac{1}{x_1}\int_{R_0}^{x_1} \frac{P c_R R}{E_R \pi k_R^2 j_R d^3}\frac{dx}{x} - \frac{1}{x_1}\int_{R_0}^{x_1}\frac{P c_R}{E_R \pi k_R^2 j_R d^3}dx - \frac{1}{x_1}\int_{R_0}^{x_1}\frac{\pi c_R E_c (R-x) k_c^2 j_c d^3}{c_c E_R \pi k_R^2 j_R d^3}\varepsilon_c \frac{dx}{x}$$

$$= \frac{1}{x_1}\int_{R_0}^{x_1}\frac{P c_R R}{E_R \pi k_R^2 j_R d^3}\frac{dx}{x} - \frac{1}{x_1}\int_{R_0}^{x_1}\frac{P c_R}{E_R \pi k_R^2 j_R d^3}dx - \frac{1}{x_1}\int_{R_0}^{x_1}\frac{c_R E_c k_c^2 j_c}{c_c E_R k_R^2 j_R} R \varepsilon_c \frac{dx}{x} + \frac{1}{x_1}\int_{R_0}^{x_1}\frac{c_R E_c k_c^2 j_c}{c_c E_R k_R^2 j_R}\varepsilon_c \, dx$$

$$= \frac{1}{x_1}\frac{P c_R}{E_R \pi k_R^2 j_R d^3}\left[R \log\frac{x_1}{R_0} - (x_1 - R_0)\right] - \frac{1}{x_1}\frac{c_R E_c k_c^2 j_c}{c_c E_R k_R^2 j_R}\left[R \log\frac{x_1}{R_0} - (x_1 - R_0)\right]\varepsilon_c$$

$$\left\{1 + \frac{1}{x_1}\frac{c_R E_c k_c^2 j_c}{c_c E_R k_R^2 j_R}\left[R\log\frac{x_1}{R_0} - (x_1 - R_0)\right]\right\}\varepsilon_c = \frac{1}{x_1}\frac{P c_R}{E_R \pi k_R^2 j_R d^3}\left[R\log\frac{x_1}{R_0} - (x_1 - R_0)\right]$$

$$\varepsilon_c = \frac{\frac{1}{x}\frac{P c_R}{E_R \pi k_R^2 j_R d^3}\left[R\log\frac{x}{R} - (x - R_0)\right]}{1 + \frac{1}{x_1}\frac{c_R E_c k_c^2 j_c}{c_c E_R k_R^2 j_R}\left[R\log\frac{x}{R_0} - (x - R_0)\right]} \qquad (5)$$

Rewriting equation (3) and substituting values for I_R and I_c

$$\varepsilon_R = \frac{P c_R}{E_R \pi k_R^2 j_R d^3}\left(\frac{R}{x} - 1\right) - \frac{c_R E_c k_c^2 j_c}{c_c E_R k_R^2 j_R}\left(\frac{R}{x} - 1\right)\varepsilon_c \qquad (6)$$

The preceding analysis applies to cantilever flat slabs loaded at the perimeter. A similar analysis might easily be worked up for slabs with a uniform load.

The curves on page 118 show values of coefficients of $\frac{P}{E_R}$ for obtaining ε_c and ε_R for compression worked out according to equations (5) and (6) for slab 1246 which contained radial and circumferential reinforcement. It will be noted that these curves resemble similar ones from the actual tests in shape. In obtaining the plotted values $\frac{E_c}{E_R}$ is considered to be equal to 1. The values of k_R and j_R have been obtained from the straight line formula by considering an average k and j over sections from R_o to x and k_c and j_c by considering an average k and j over the section from x to R. A value of $n = 15$ has been used. It is realized that these assumptions probably make the results somewhat approximate. It is probable that E_R decreases with increasing unit deformatio enough to change the shape of a curve plotted for actual unit deformations so that it would be somewhat more concave than the one shown for the coefficients.

The following table gives the values of percentage reinforcement and the values of k and j used in calculating the coefficients of $\frac{P}{E_R}$ for obtaining ε_c and ε_R for compression for slabs with both radial and circumferential reinforcement.

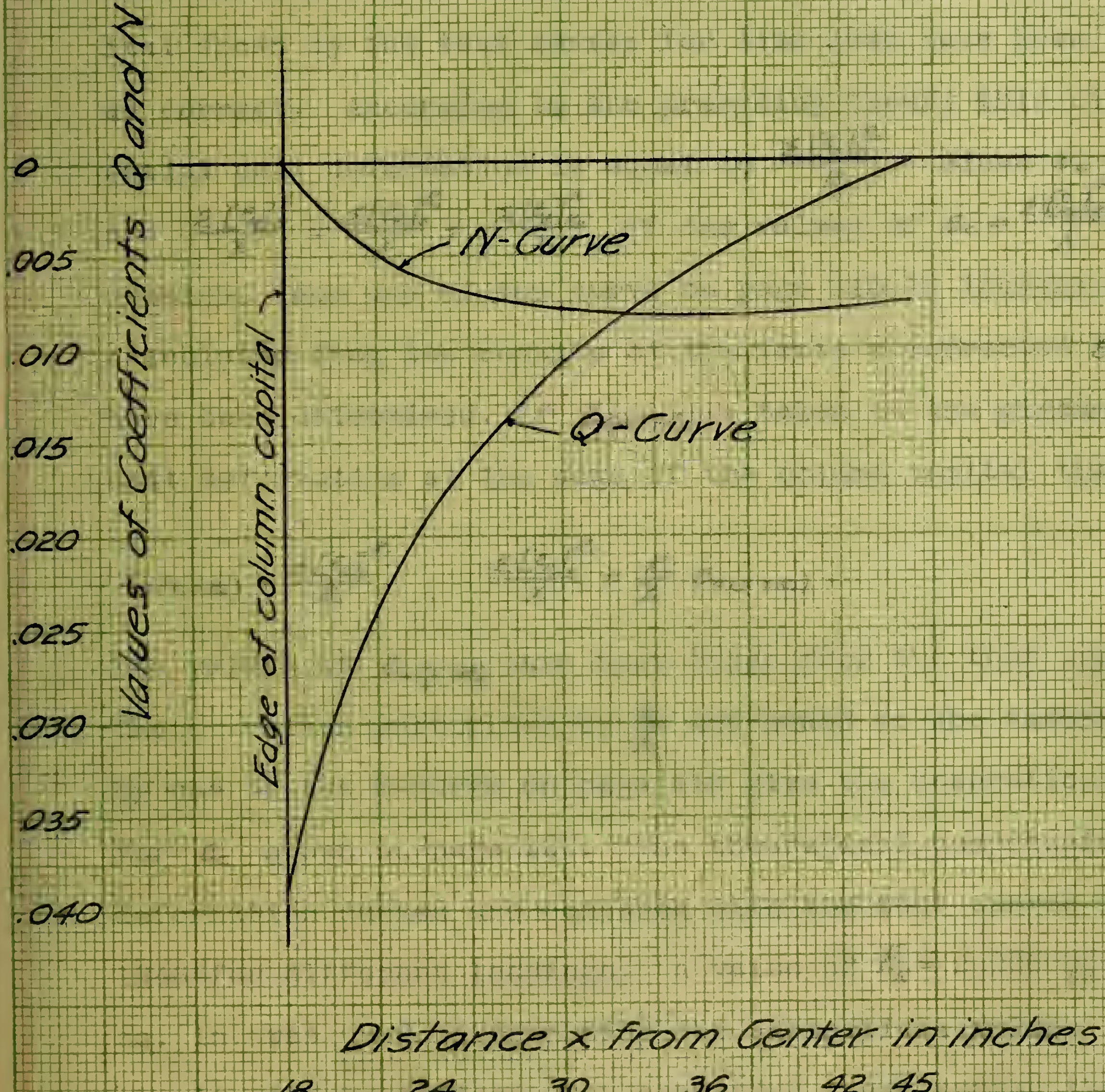
x	p_R Percent	k_R	j_R	Av. k_R	Av. j_R	p_c Percent	k_c	j_c	Av. k_c	Av. j_c	N	Q
18	1.085	.43	.86	.43	.86	.632	.35	.88	.315	.895	0	.0390
24	.815	.39	.87	.41	.865	.555	.33	.89	.305	.90	.00639	.0193
30	.652	.36	.88	.395	.87	.495	.32	.89	.30	.90	.00790	.0109
36	.543	.33	.89	.38	.875	.444	.30	.90	.29	.905	.00825	.0056
42	.466	.31	.90	.37	.88	.350	.28	.91	.28	.91	.00786	.0017
43	.435	.30	.90	.365	.88	.350	.28	.91	.28	.91	.00760	0

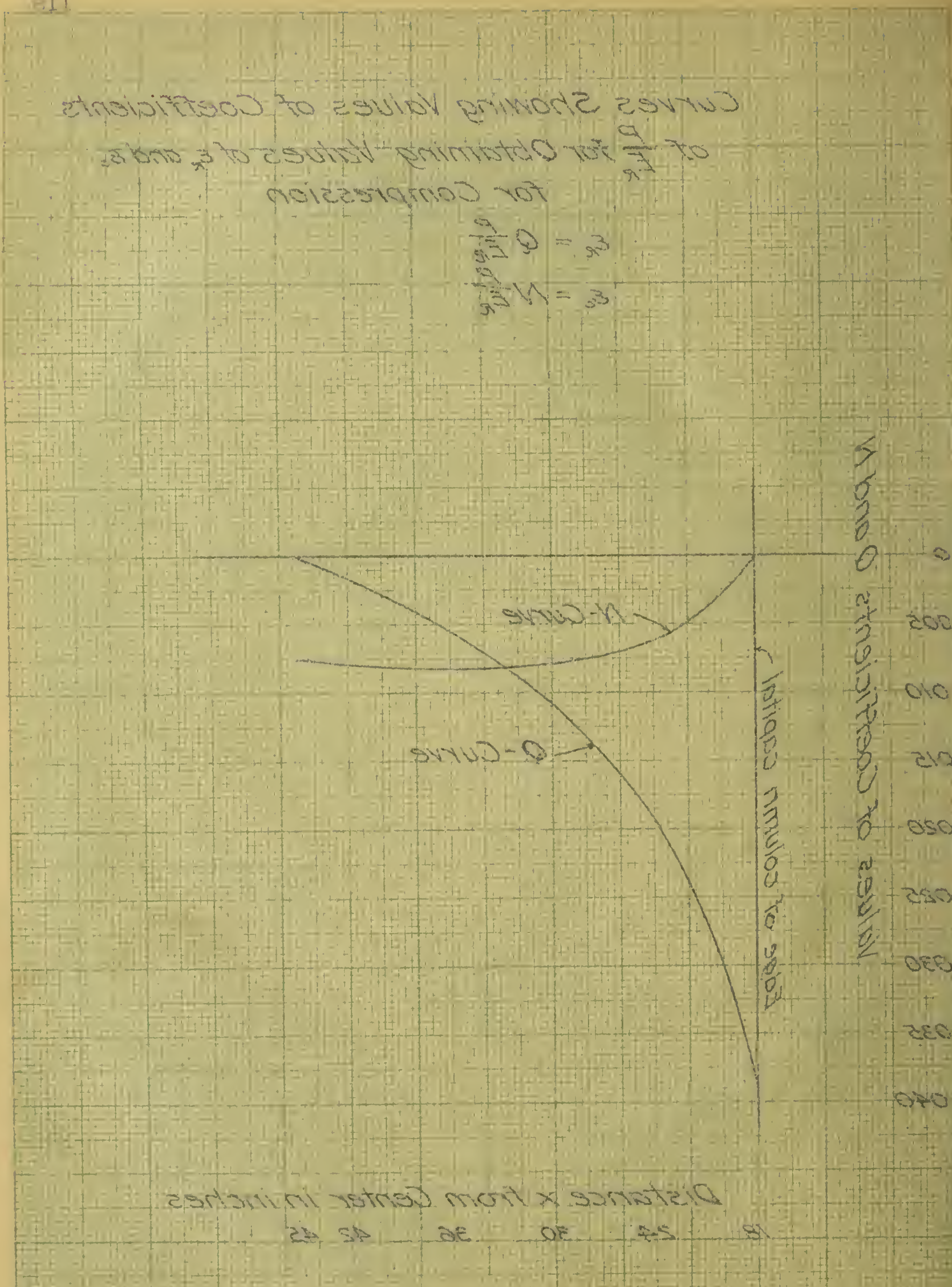
* $\varepsilon_c = N\frac{P}{E_R}$ $\quad \varepsilon_R = Q\frac{P}{E_R}$

Curves Showing Values of Coefficients of $\frac{P}{E_R}$ for Obtaining Values of ε_R and ε_c for Compression

$$\varepsilon_R = Q\frac{P}{E_R}$$

$$\varepsilon_c = N\frac{P}{E_R}$$



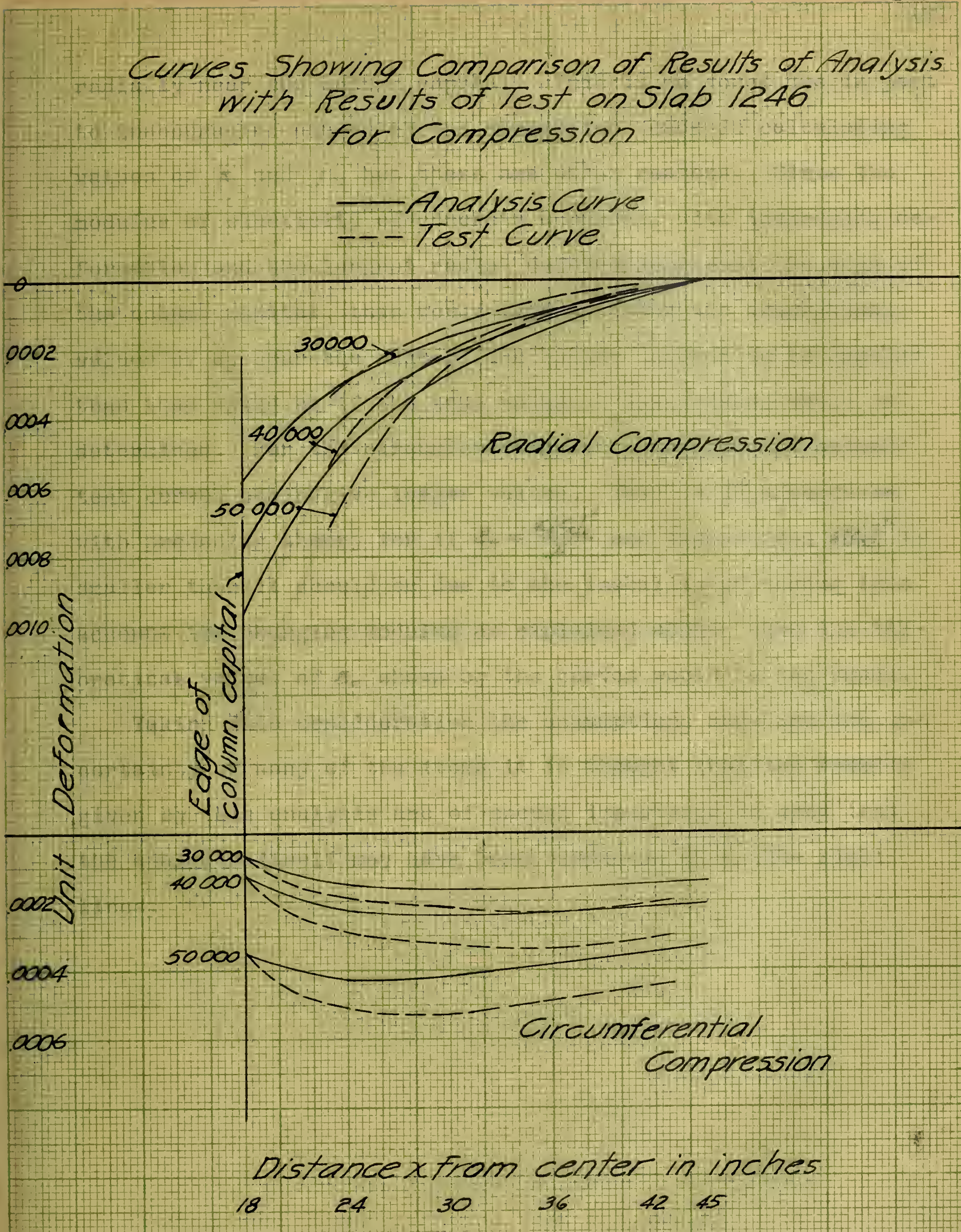

Curves Showing Values of Coefficients
for Compression
N-Curve
Q-Curve
Edge of column capital
Values of Coefficients Q and N
0
.005
.010
.015
.020
.025
.030
.035
.040
Distance x from Center in inches
18 24 30 36 42 45

26. <u>Comparison of Theoretical Values with Results of Tests</u>.- As previously stated equations (5) and (6) take no account of radial deformation inside the edge of the column capital, as there is no way to determine its value theoretically. That such deformation does exist is shown by the results of the tests. In order to obtain curves from equations (5) and (6) to compare with those plotted from results of the tests the circumferential unit deformation in compression at the edge of the column capital shown by the test curves for slab 1246 have been assumed as correct. According to the preceding theory this circumferential unit deformation is equal to $\frac{\Sigma[\varepsilon_R]_0^{R_0}}{R_0}$. Since $\varepsilon_c = \frac{\Sigma[\varepsilon_R]_0^{x}}{x}$ and $\frac{\Sigma[\varepsilon_R]_0^{x}}{x} = \frac{\Sigma[\varepsilon_R]_0^{R_0}}{x} + \frac{\Sigma[\varepsilon_R]_{R_0}^{x}}{x}$ if the values of $\varepsilon_c = \frac{\Sigma[\varepsilon_R]_{R_0}^{x}}{x} = N\frac{P}{E_R}$ obtained from use of the curve on page 118 be increased by $\frac{\Sigma[\varepsilon_R]_0^{R_0}}{x}$ calculated from the results of the tests a corrected ε_c will have been determined. If $\varepsilon_{c(x=R_0)}$ is taken as the circumferential unit deformation at the edge of the column capital then,

$$\varepsilon_{c(x=R_0)} = \frac{\Sigma[\varepsilon_R]_0^{R_0}}{R_0} \qquad \frac{\Sigma[\varepsilon_R]_0^{R_0}}{x} = \frac{R_0}{x}\,\varepsilon_{c(x=R_0)}$$

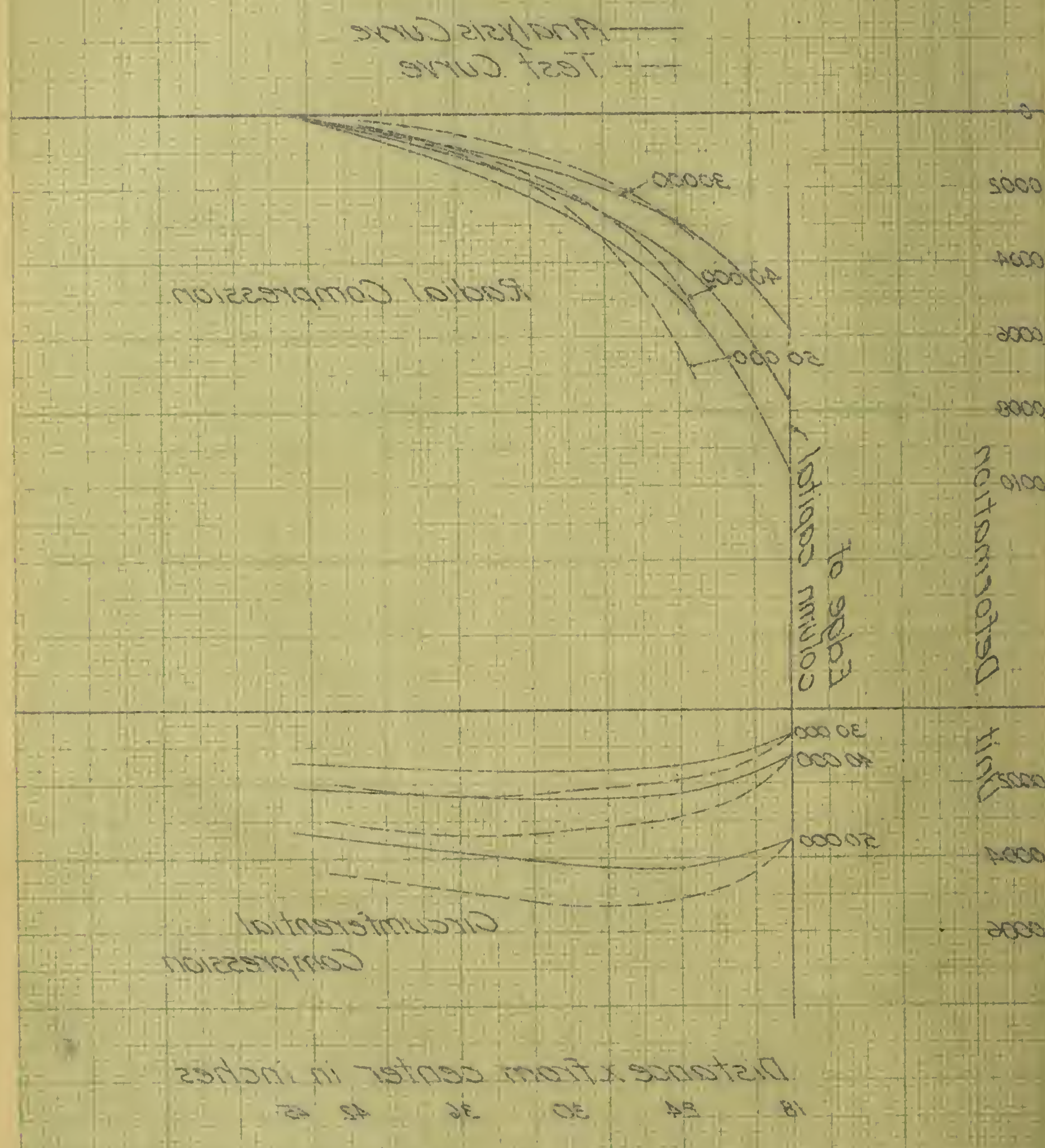
The values of $\varepsilon_{c(x=R_0)}$ have been taken from the test curves. These values multiplied by $\frac{R_0}{x}$ and added to the values obtained by use of the N-curve on page 118 give the theoretical results for ε_c shown on page 120. The theoretical compression unit deformation curves are compared with the test curves for slab 1246 for different loadings. A value of E_R = 2 000 000 lb. per sq. in. was used in computing the theoretical values.

It will be noticed upon examining these curves that the unit deformations from the test exceed the theoretical values



Curves Showing Comparison of Results of Analysis with Results of Test on Slab 1246 for Compression
Analysis Curve
Test Curve
0
.0002
.0004
.0006
.0008
.0010
.0002
.0004
.0006
Unit Deformation
Edge of column capital
30000
40000
50000
Radial Compression
30 000
40 000
50 000
Circumferential Compression
Distance x from center in inches
18
24
30
36
42
45

Curves Showing Comparison of Results of Analysis with Results of Test on Slab 1246 for Compression



radially near the column capital. This is no doubt due in part to inaccuracies caused by the assumptions made in calculating values of k and j, but there are other reasons. Since the modulus of elasticity of concrete decreases with increasing deformation and the largest radial deformations next the edge of the column capital, this would tend to cause the theoretical values of $\mathcal{E}_r$ near the edge of the column capital to be smaller than they would be if the true value of the modulus could be determined. For the circumferential deformations the actual test curves again give larger values. This is in accordance with preceding theory for if $\mathcal{E}_c = \frac{\Sigma[\mathcal{E}_r]_0^x}{x}$ and theoretical $\Sigma[\mathcal{E}_r]_0^x$ is smaller than it should be due to the inability of taking into account the changing modulus as explained above, then the theoretical values of $\mathcal{E}_c$ shown by the curves would be too small.

Taking into consideration the assumptions made and the uncertainty of many of the items it is thought that the results given by this analysis are of enough importance to show that the analysis itself may have been conducted along the right lines.

IV. CONCLUSIONS

IV. CONCLUSIONS.

23. Summary of Conclusions.- The conclusions reached by a study of the data of these tests and the theory and analysis may be briefly summarized. These conclusions may not apply to forms of construction which differ much from the specimens used in the tests, but should apply in part to flat slab floors by considering the line of inflection around the column capital to be nearly circular and the load outside this line of inflection going to that particular column under consideration to be suspended at the line of inflection. The conclusions follow.

1. The test specimens were not designed and constructed to produce the best possible results in respect to ultimate strength. The hoops should have been spaced closer at sections distant from the edges of the column capitals, and the radial rods should have been welded to the plates to prevent slipping of the rods. That this was not done was through no fault of the department under whose direction the tests were conducted.

2. Circumferential reinforcement in the form of hoops acted to increase the strengths of the specimens containing them by resisting flexure. It was impossible to determine definitely from the tests whether or not the hoops were stressed by a pressure of the concrete against their inner surfaces in a manner similar to fluid pressure in circular tanks, but the formation of circumferential cracks tangent to the outside perimeters of the hoops indicated that such a condition was possible.

3. It would seem from a comparison of the ultimate loads

and the load-deformation curves that the hoops were not as efficient in producing strength as equal volumes of steel placed radially. The slabs reinforced with hoops deflected very much less at the ultimate loads than those without hoops, which indicates that circumferential reinforcement stiffens a slab if placed below the neutral axis on the tension side.

4. The form of reinforcement had a decided effect on the manner of failure of the specimens. Slabs containing circumferential rods as the only reinforcement failed by punching through or from circumferential cracks, while those containing radial reinforcement only failed from radial cracks together with slipping of the rods at their connections with the plates. Slabs reinforced with both radial and circumferential rods punched through after both the radial and circumferential steel had been stressed to the yield point. The multitude of cracks remained small up to the ultimate loads, which indicates that there was no special weakness with this form of reinforcement. The slab containing two layers of reinforcing rods placed at right angles failed from tension in the steel. With hoops as the only reinforcement a sudden failure might be expected.

5. The effect of the form of reinforcement on ultimate loads was quite marked. The slab with the rectangular form of reinforcement carried about 18 % greater load than slabs with both radial and circumferential rods which had the same volume of steel outside the edges of the column capitals. If the hoops had been spaced to better advantage and the radial rods welded to the plates, it is possible however that the latter specimens

would have taken as much load as the former one. The slabs with radial rods as the only reinforcement carried about 32 % greater loads than those with hoops as the only reinforcement.

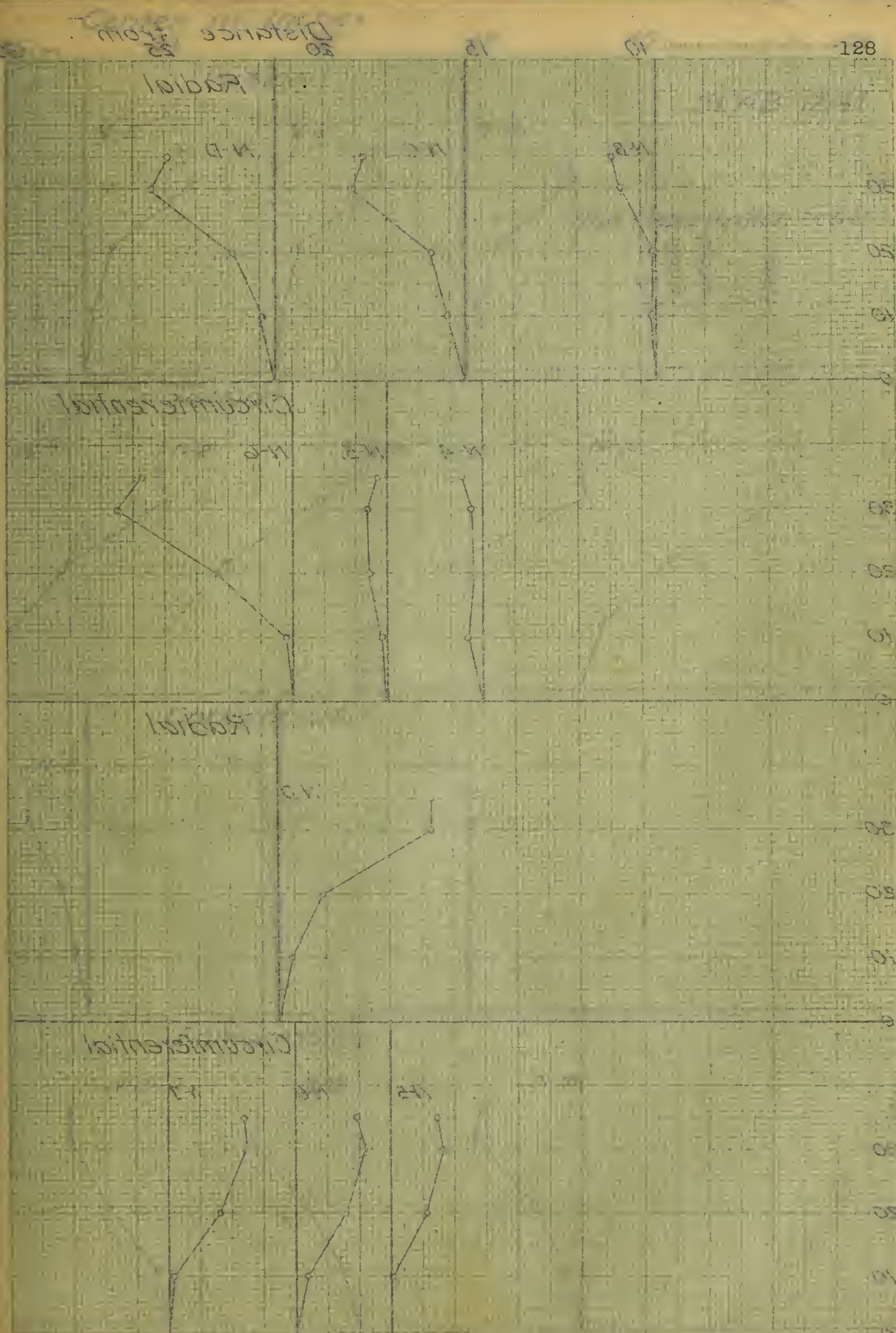
6.The effect of the form of reinforcement on the distribution of the stresses as indicated by the deformations was not made clear by a study of the results of the tests. This was partly due to the fact that the measured circumferential deformations for the slabs with radial rods as the only reinforcement were unreliable because of the large radial cracks which formed at an early stage of the tests. A comparison of the results of the test of the slab with the rectangular form of reinforcement with the results of tests of the slabs with both radial and circumferential reinforcement indicates that rods placed in two layers at right angles act as both radial and circumferential reinforcement.

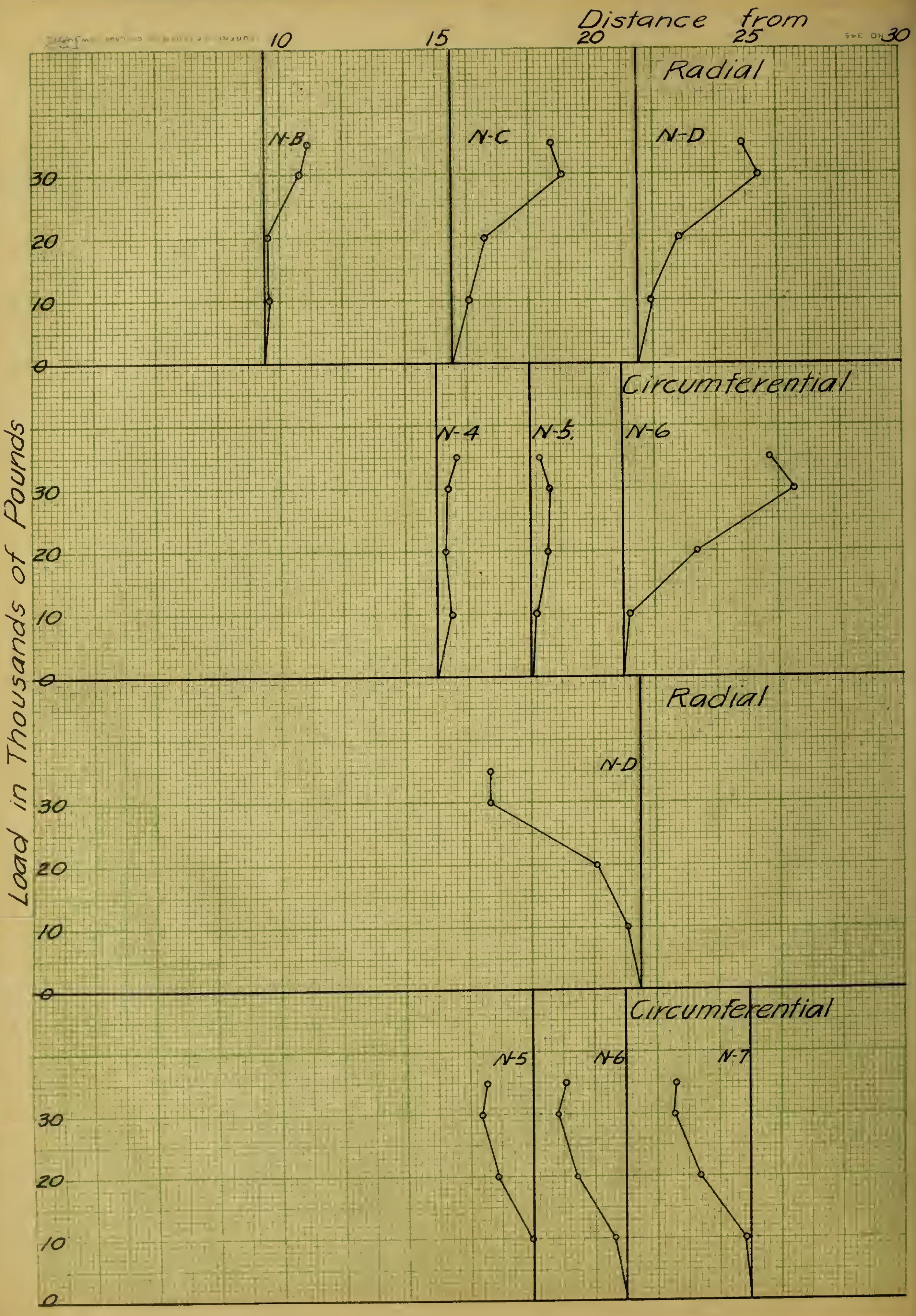
7. The radial unit deformations reached their maximum values near the edges of the column capitals. The compression radial unit deformations decreased very rapidly with the distance from the edges of the column capitals. The circumferential unit deformations increased to sections about mid-way between the edges of the column capitals and the edges of the slabs, then decreased slowly with the remaining distance to the edges of the slabs.

8. The analysis contained in this thesis gives values which, when plotted, determine curves of a similar form to the load-deformation curves obtained from the results of the tests. The theory upon which the analysis is based which states that

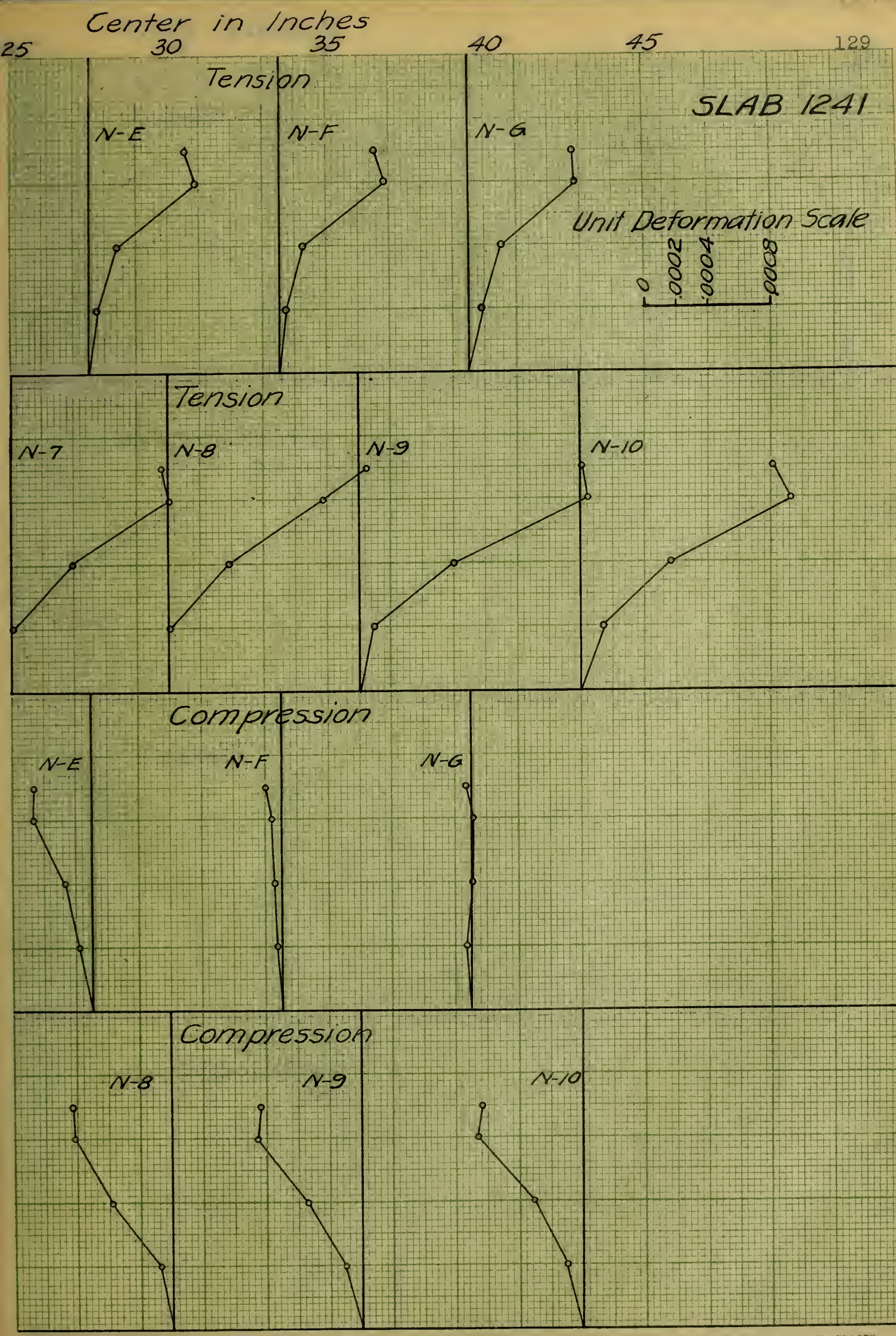
the circumferential unit deformations at any section are equal to the average radial unit deformations over a distance from the center to that section would seem to be well founded.

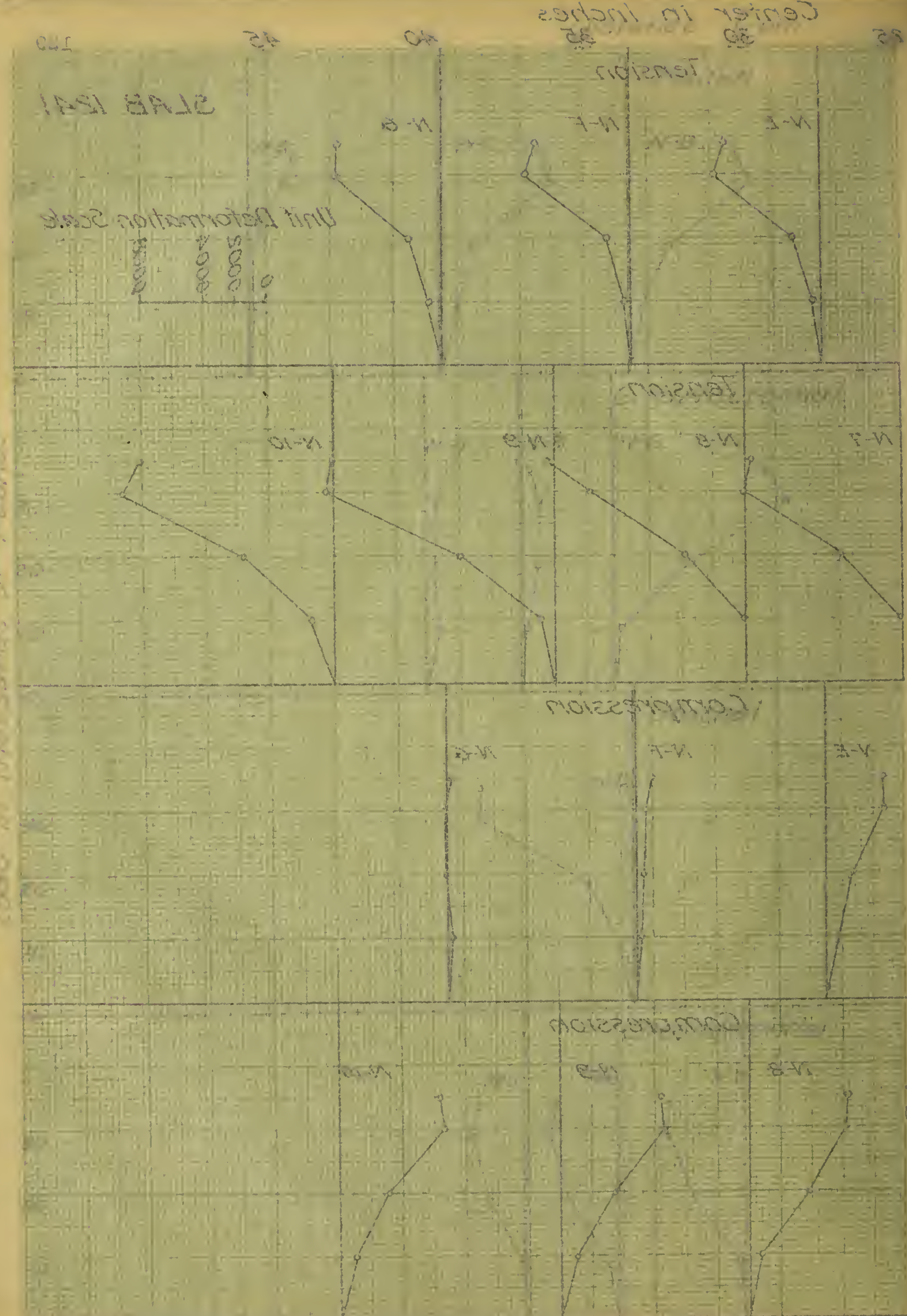
V. DIAGRAMS



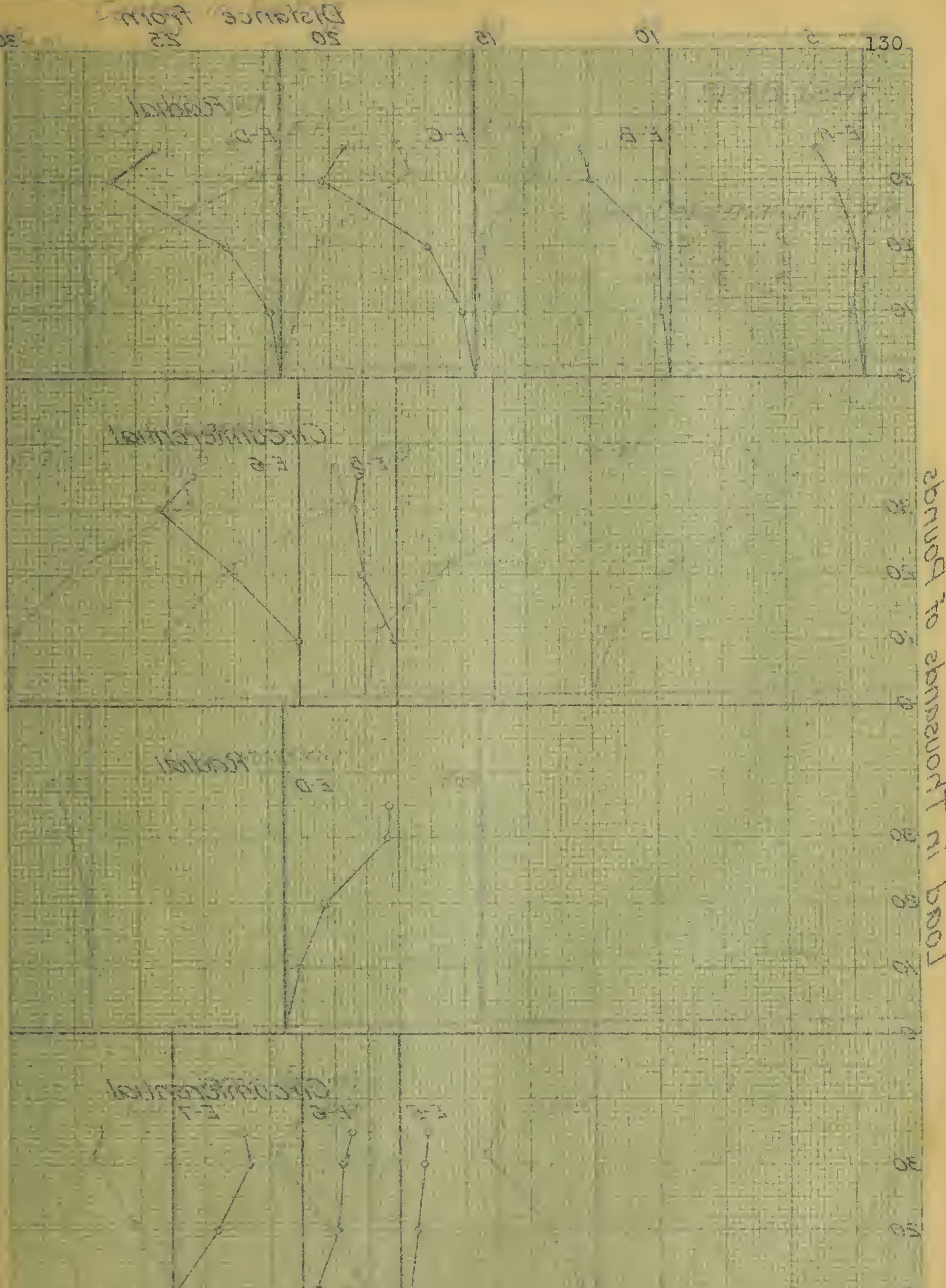


Distance from
10
15
20
25
30
Radial
N-B
N-C
N-D
Circumferential
N-4
N-5
N-6
Radial
N-D
Circumferential
N-5
N-6
N-7
Load in Thousands of Pounds
0
10
20
30

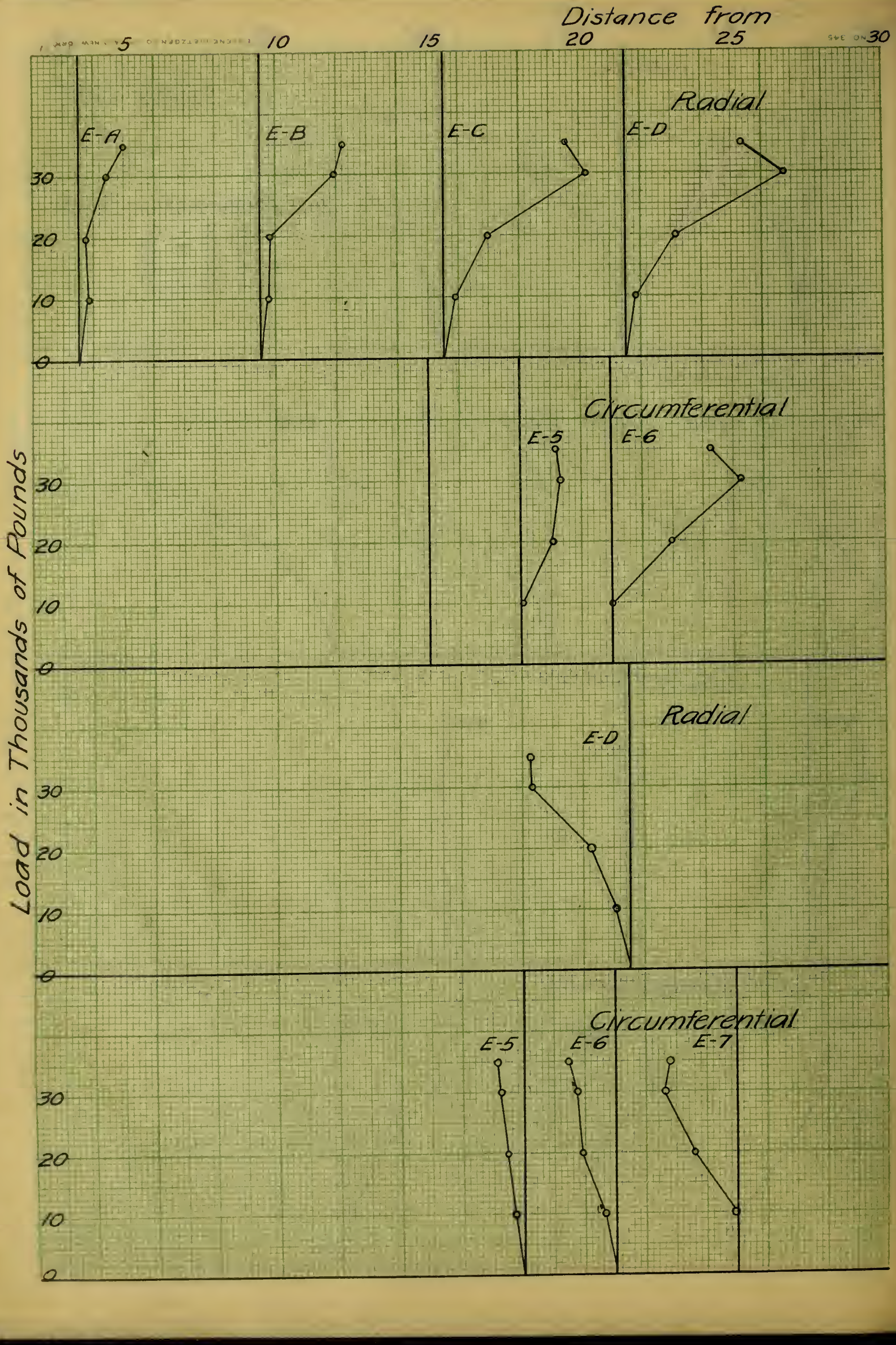

Center in Inches
25
30
35
40
45
SLAB 1241
Tension
N-E
N-F
N-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
N-7
N-8
N-9
N-10
Compression
N-E
N-F
N-G
Compression
N-8
N-9
N-10
NO 345
EUGENE DIETZGEN CO. CHICAGO NEW YORK



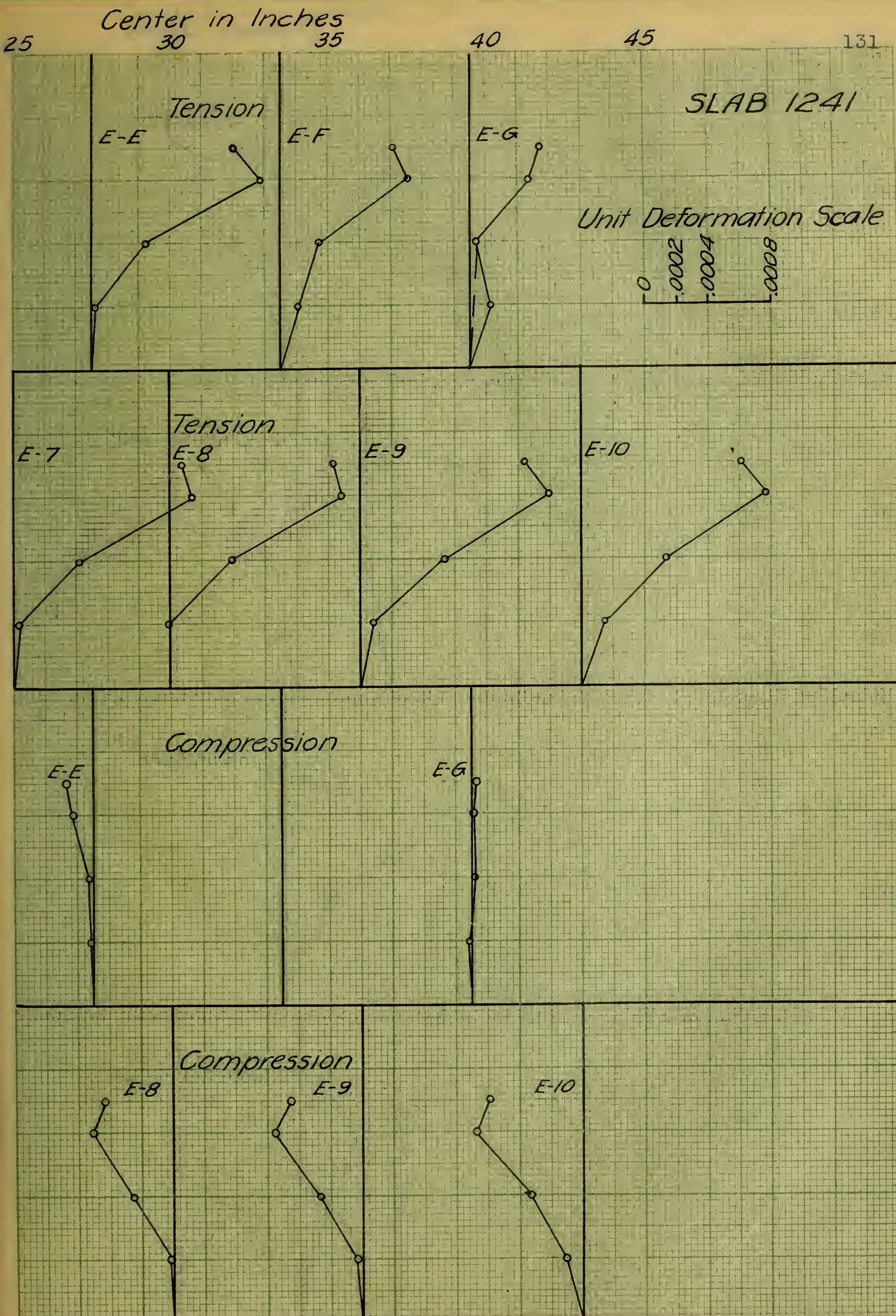
Center in Inches
25
30
35
40
45
SLAB 1241
Unit Deformation Scale
0
.0002
.0004
.0006
Tension
N-2
N-4
N-6
N-7
N-8
N-9
N-10
Compression
N-2
N-4
N-6
N-8
N-9
N-10

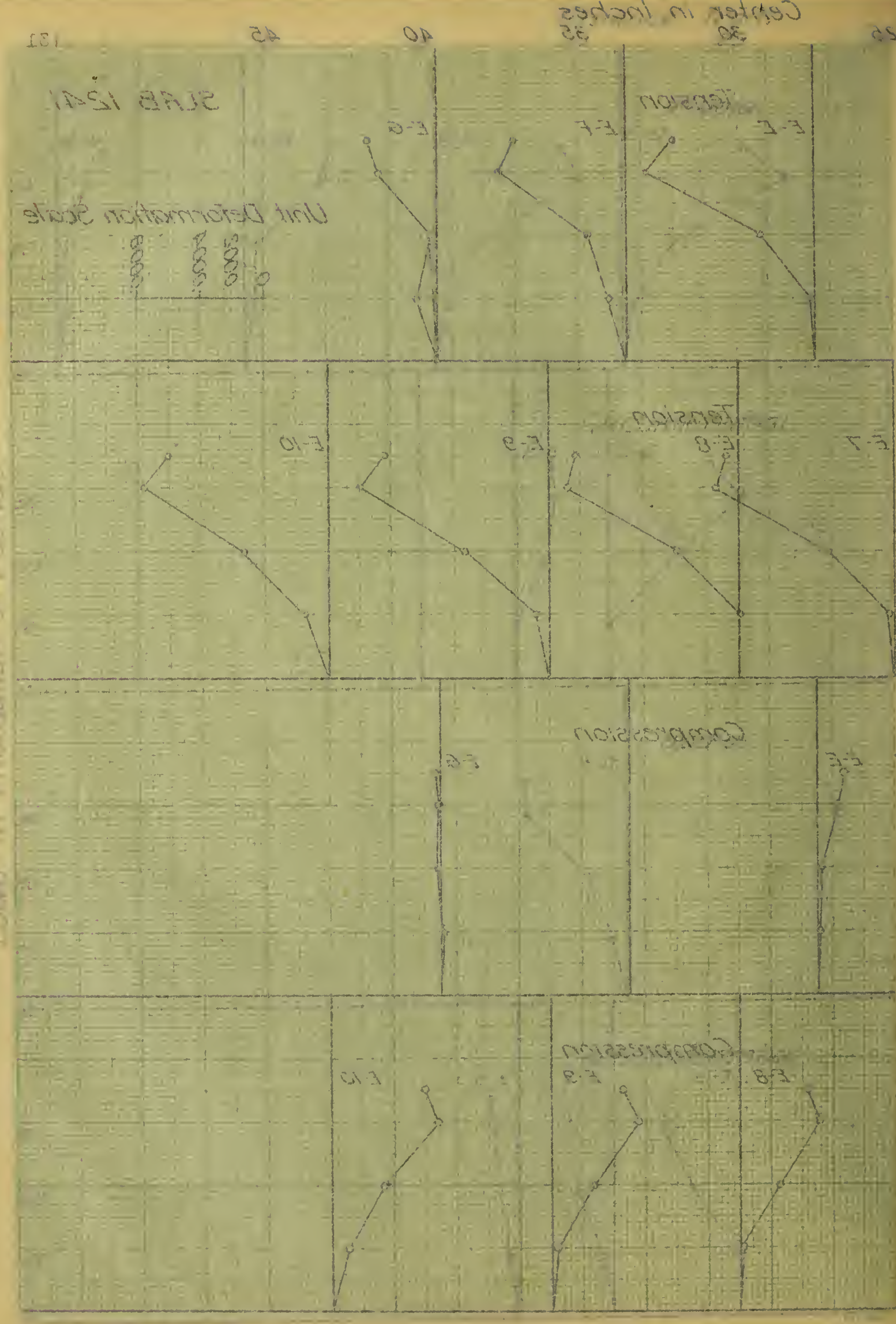


Distance from
Load in Thousands of Pounds
Radial
Circumferential

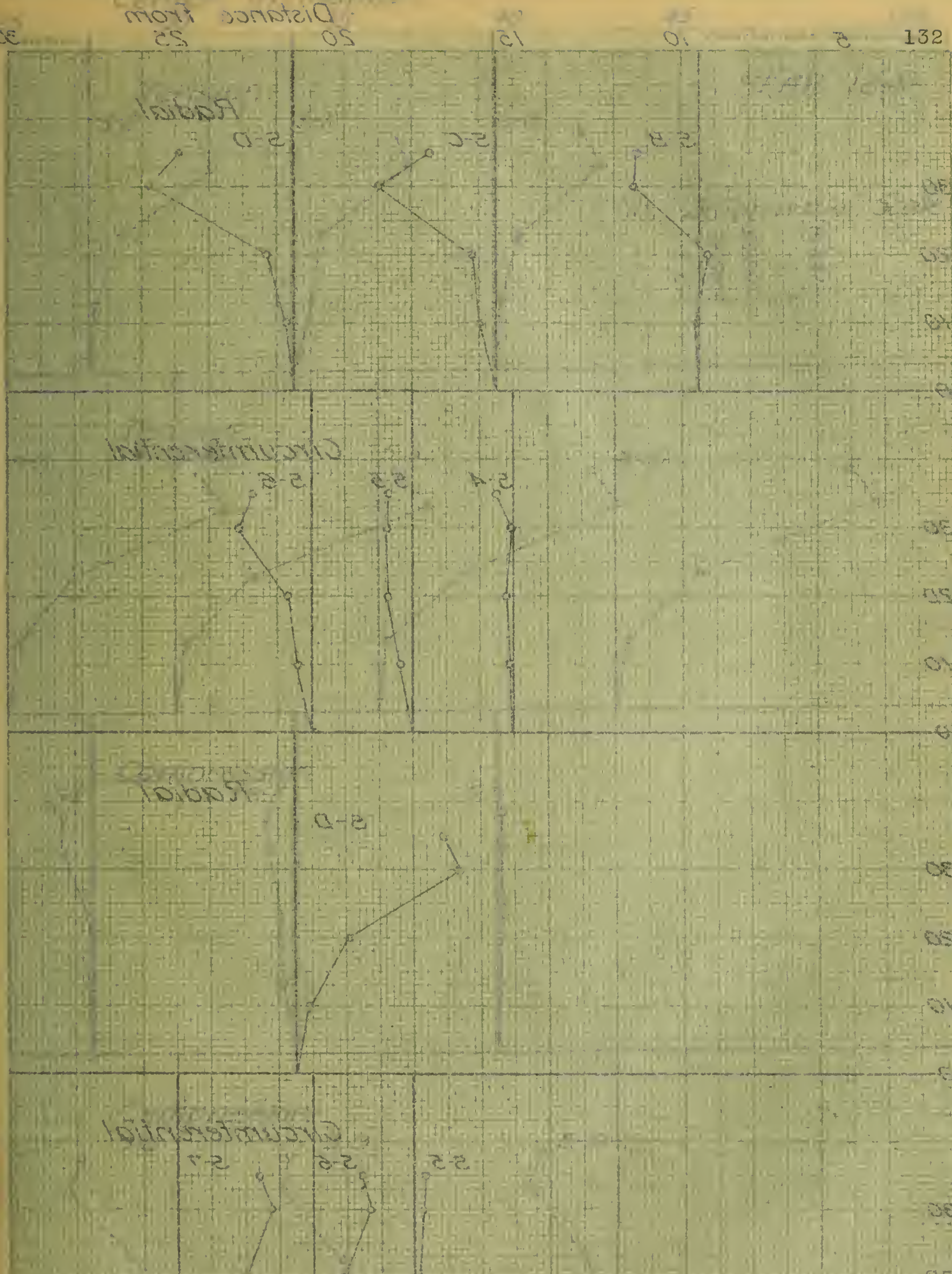


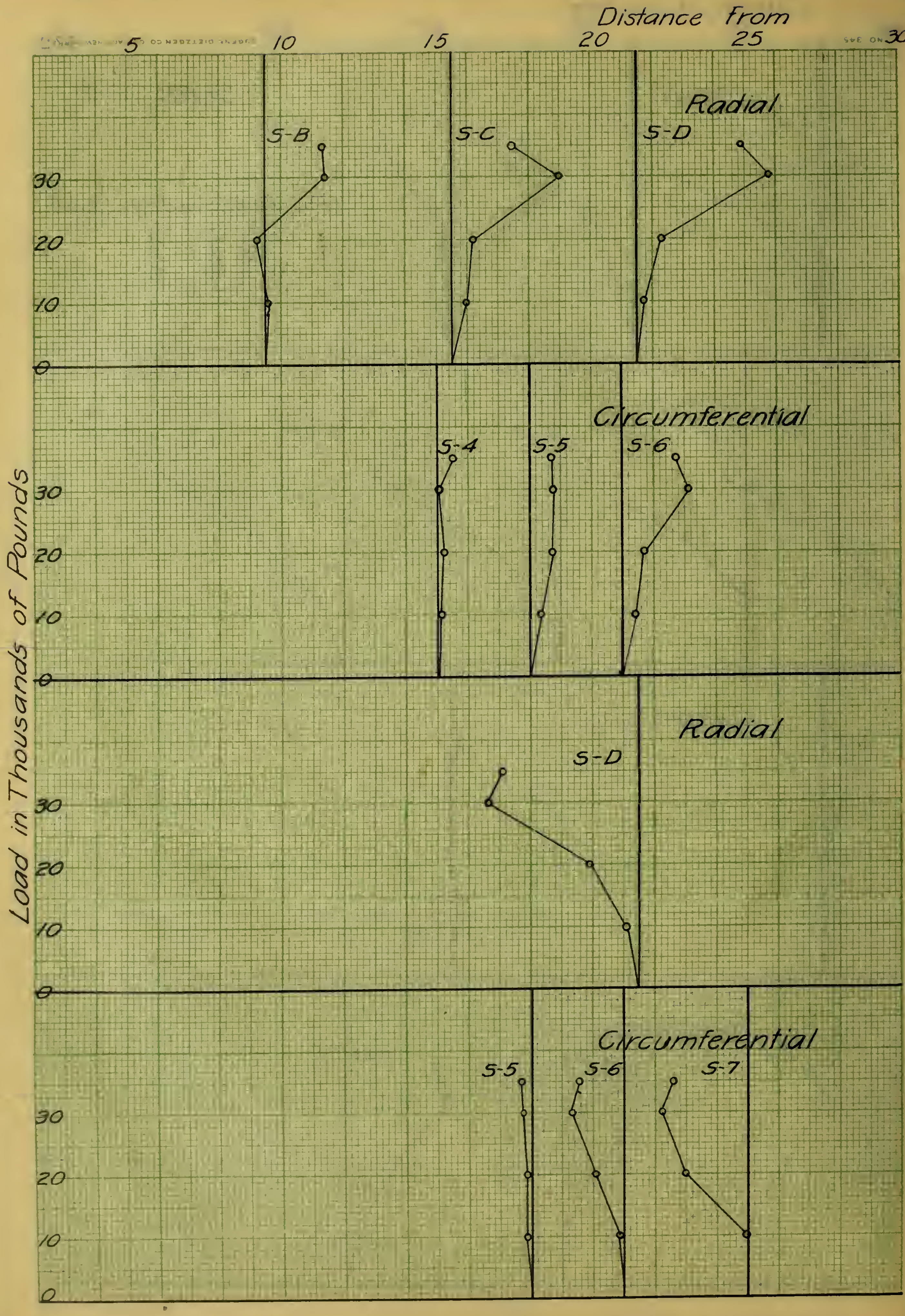
Distance from
5
10
15
20
25
30
Radial
E-A
E-B
E-C
E-D
Circumferential
E-5
E-6
Radial
E-D
Circumferential
E-5
E-6
E-7
Load in Thousands of Pounds
0
10
20
30


Center in Inches
25
30
35
40
45
SLAB 1241
Tension
E-E
E-F
E-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E-7
E-8
E-9
E-10
Compression
E-E
E-G
Compression
E-8
E-9
E-10

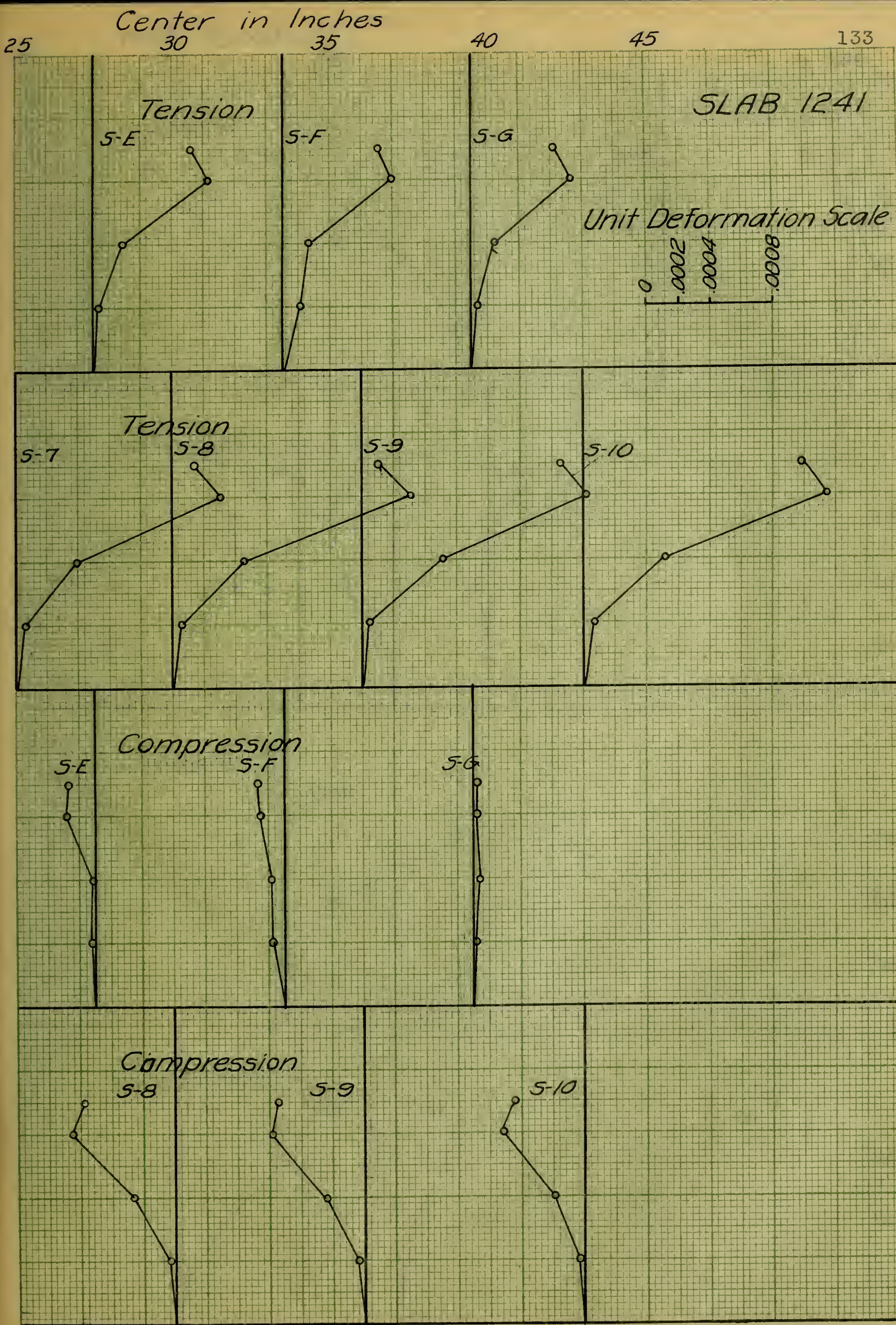


Center in Inches
25
30
35
40
45
SLAB 12-41
Unit Deformation Scale
Tension
E-5
E-6
E-7
E-8
E-9
E-10
Compression
Load in Thousands of Pounds

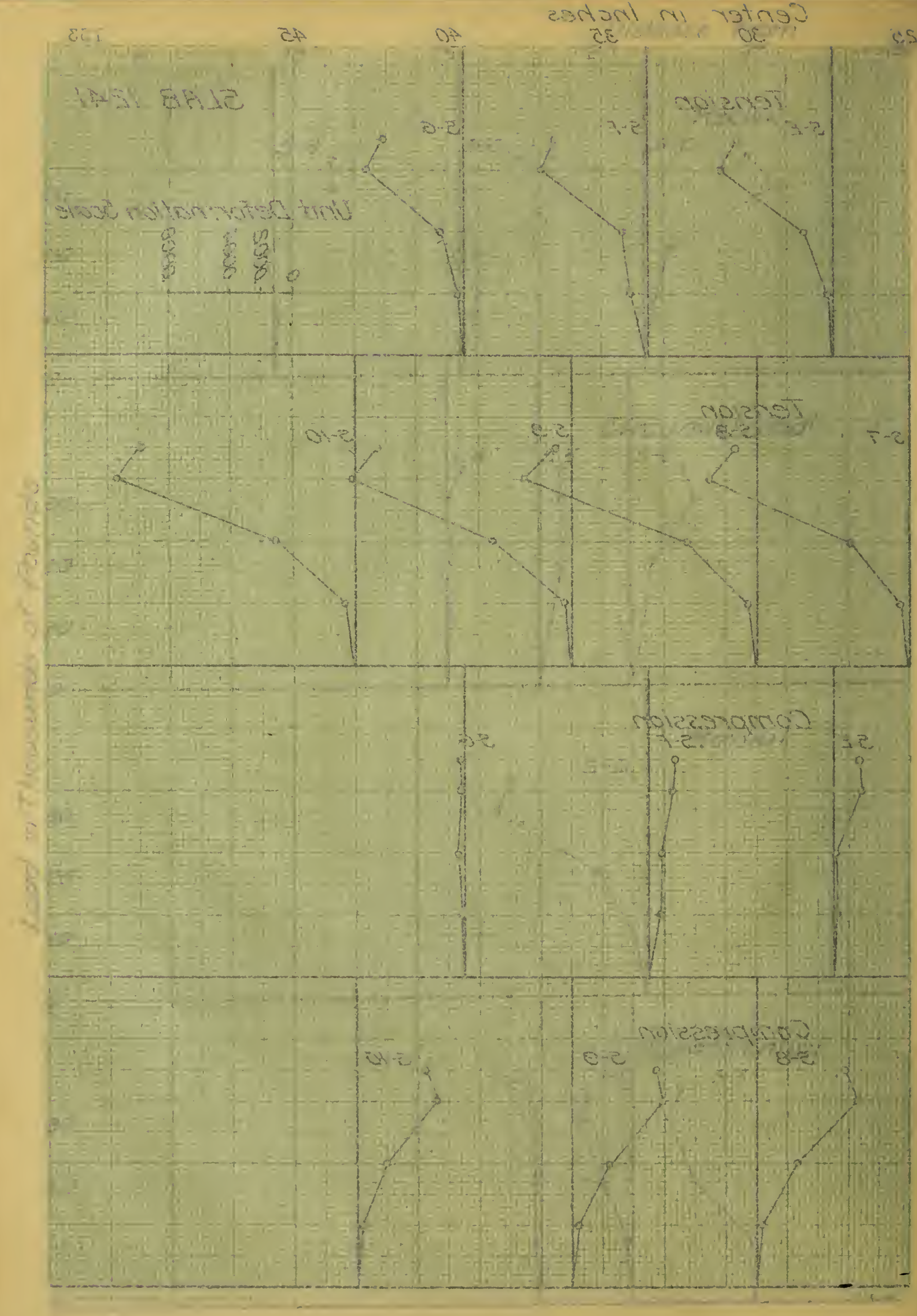

Distance from
Radial
Circumferential
Radial
Circumferential
Load in Thousands of Pounds



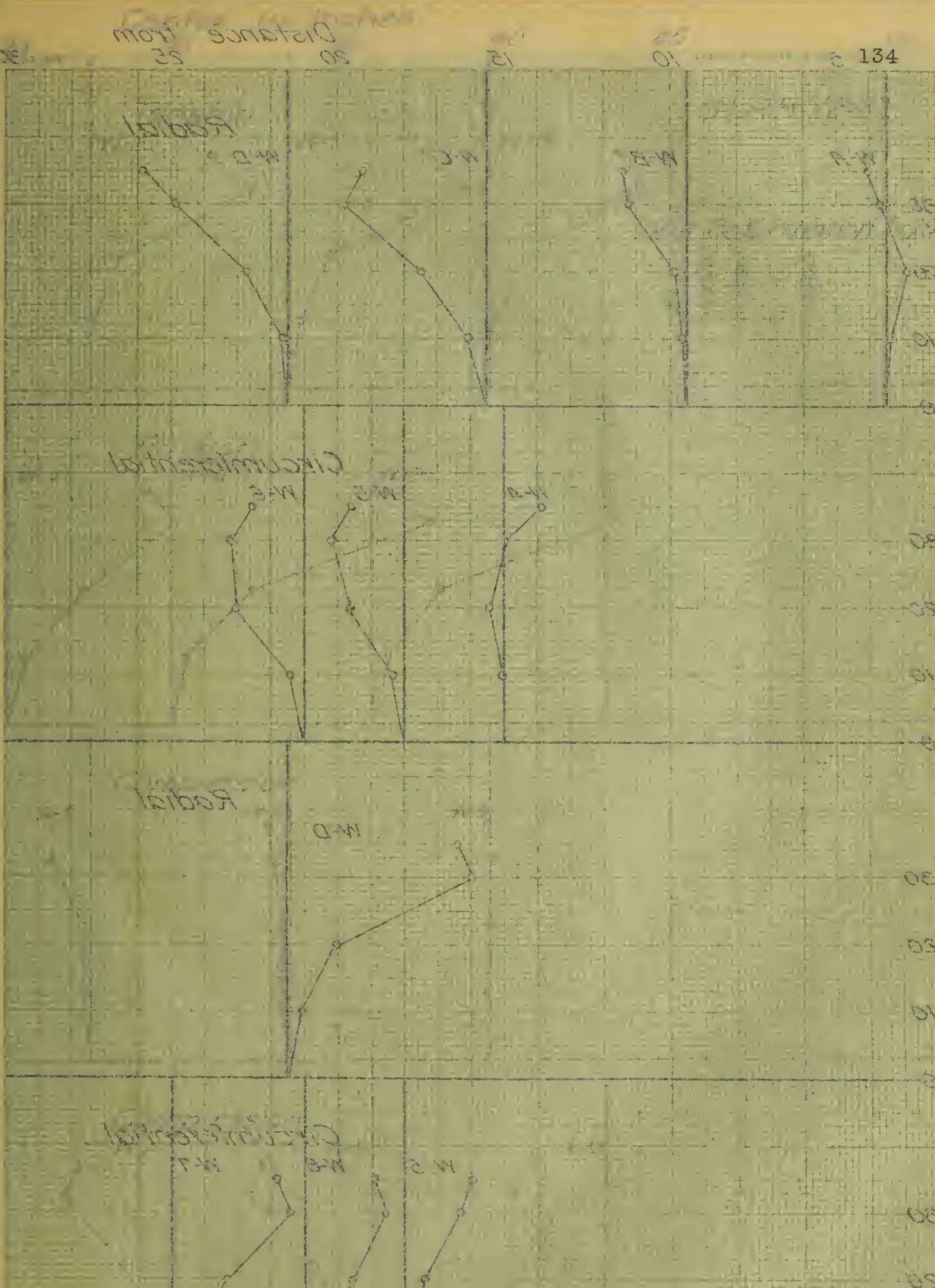
Distance from
5
10
15
20
25
30
Load in Thousands of Pounds
Radial
S-B
S-C
S-D
Circumferential
S-4
S-5
S-6
Radial
S-D
Circumferential
S-5
S-6
S-7
0
10
20
30

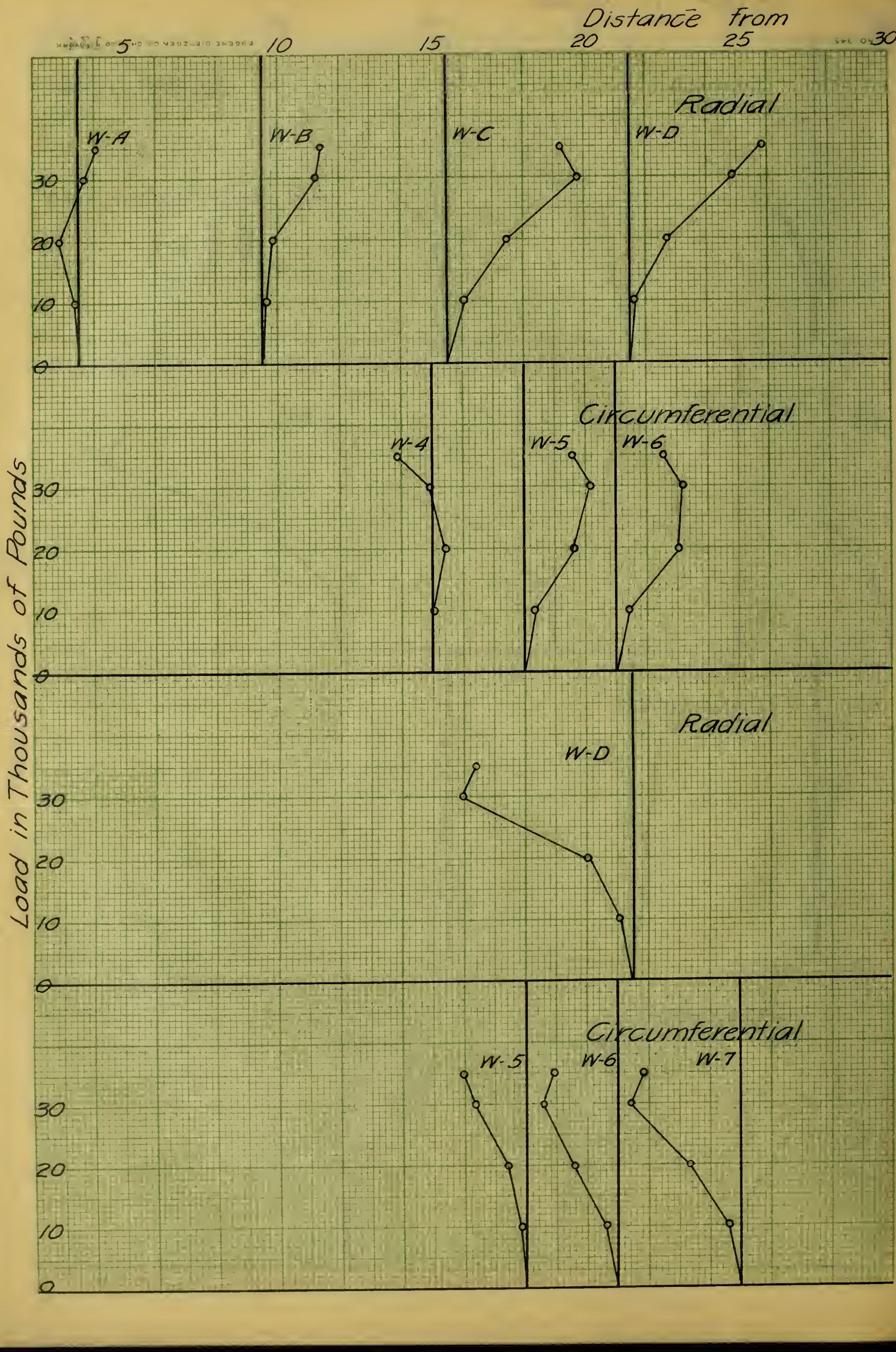


Center in Inches
25
30
35
40
45
SLAB 1241
Tension
S-E
S-F
S-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
S-7
S-8
S-9
S-10
Compression
S-E
S-F
S-G
Compression
S-8
S-9
S-10

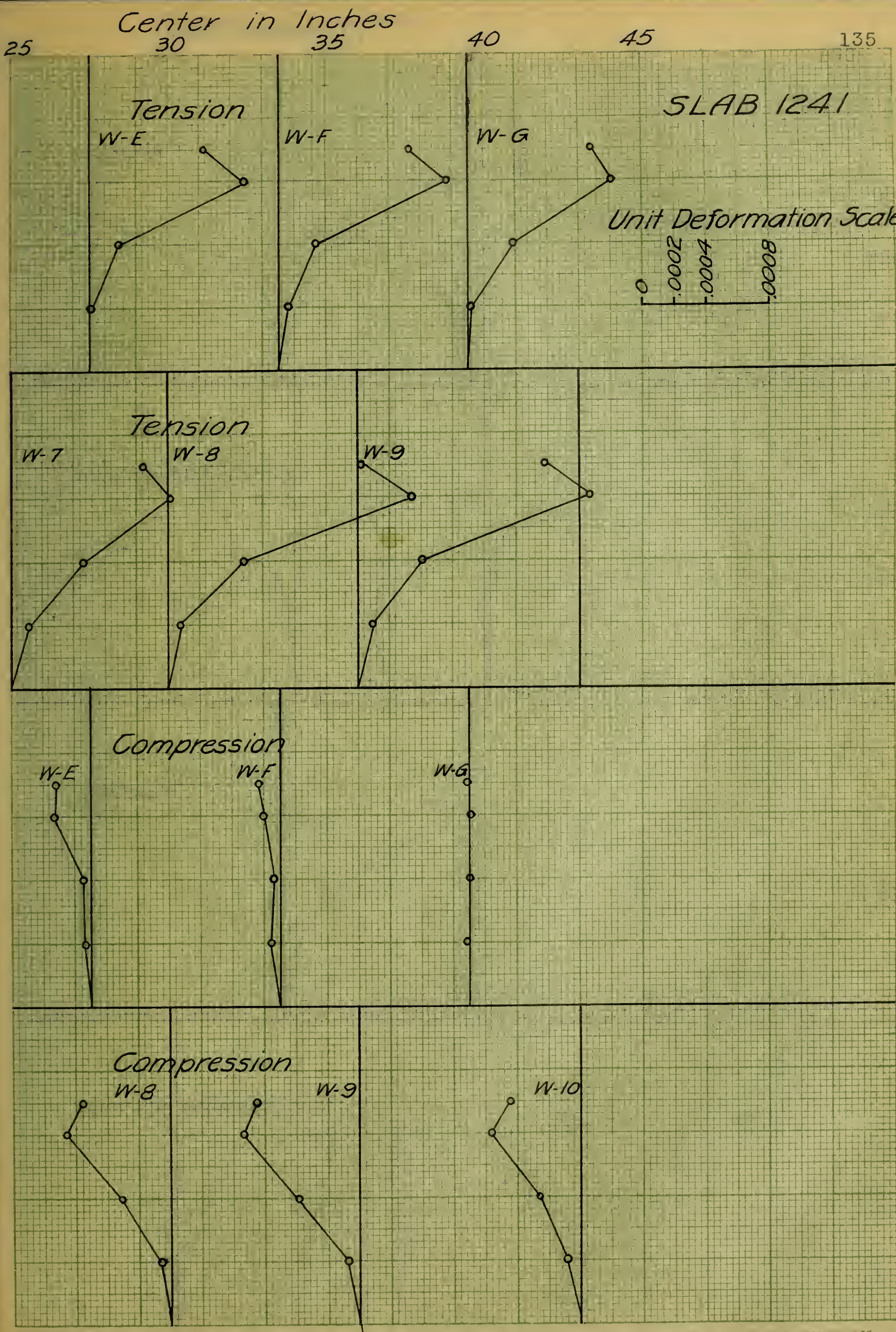


Center in Inches
SLAB 12-41
Tension
Compression
Unit Deformation Scale
S-6
S-7
S-8
S-9
S-10


Distance from Center in Inches
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential
M-D

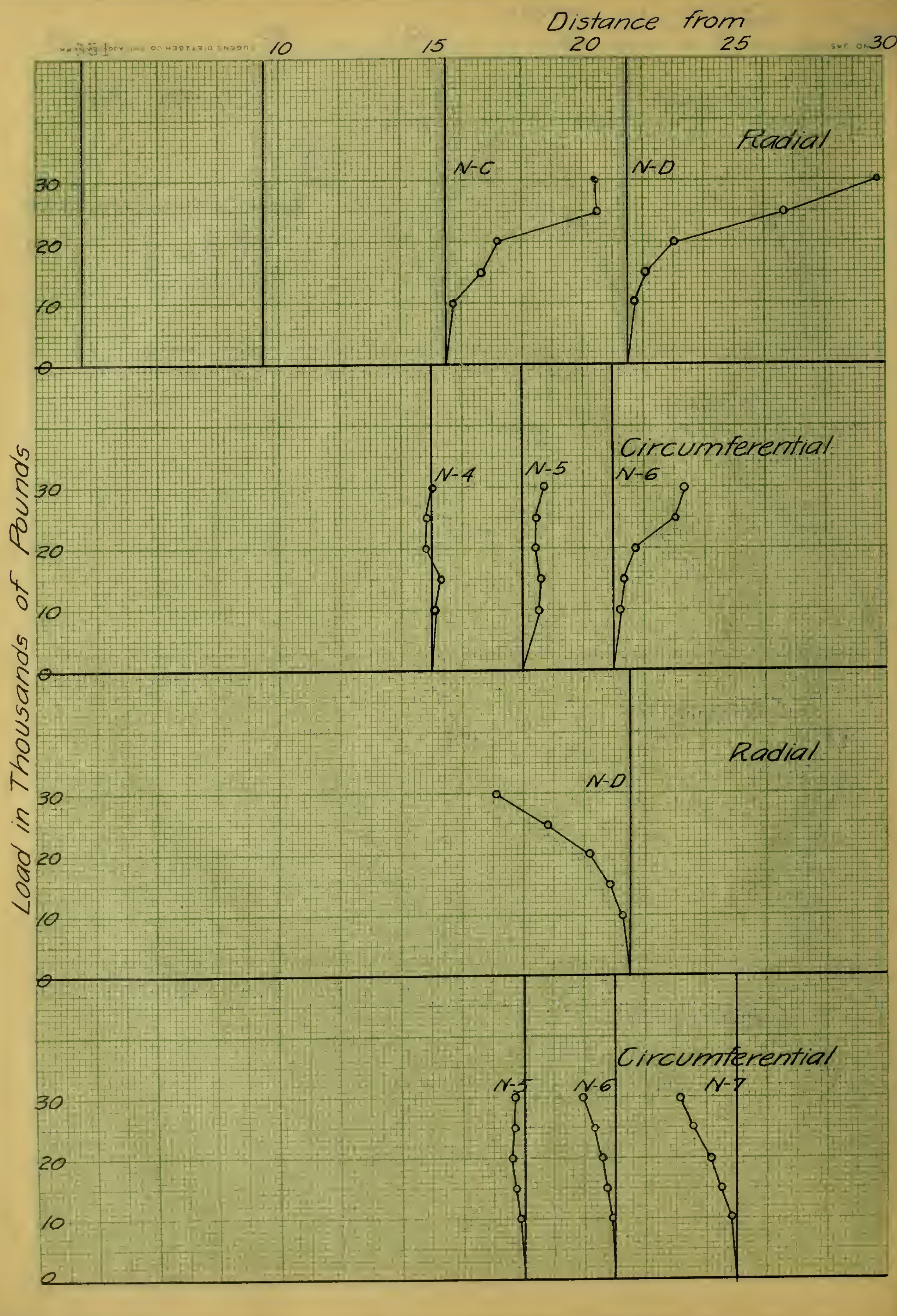


Distance from
5
10
15
20
25
30
Radial
W-A
W-B
W-C
W-D
Circumferential
W-4
W-5
W-6
Radial
W-D
Circumferential
W-5
W-6
W-7
Load in Thousands of Pounds
0
10
20
30

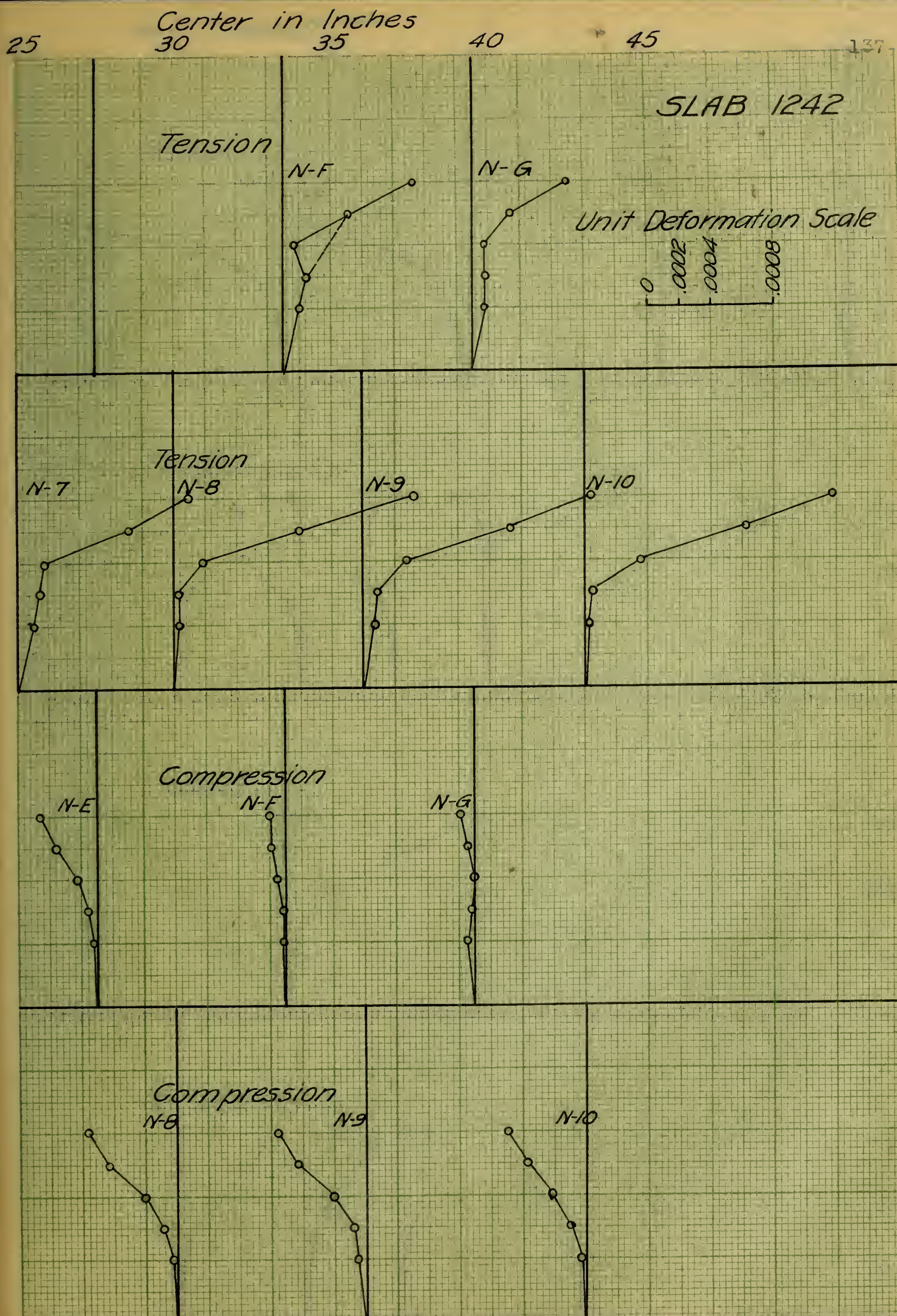

Center in Inches
25
30
35
40
45
SLAB 1241
Tension
W-E
W-F
W-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
W-7
W-8
W-9
Compression
W-E
W-F
W-G
Compression
W-8
W-9
W-10

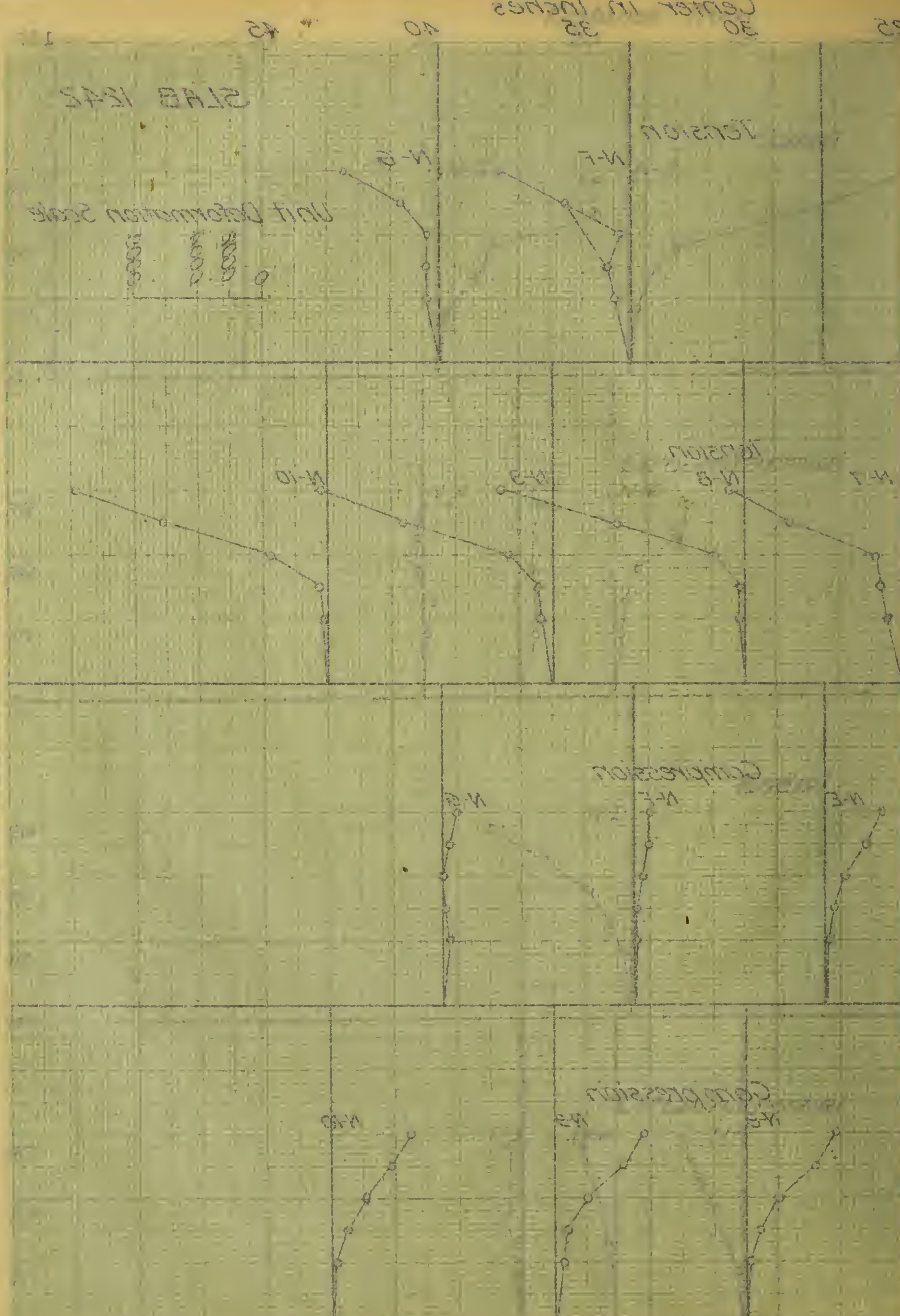

SLAB 1241
Center in Inches
25
30
35
40
45
Tension
Compression
Unit Deformation Scale
Load in Thousands of Pounds


Distance from
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

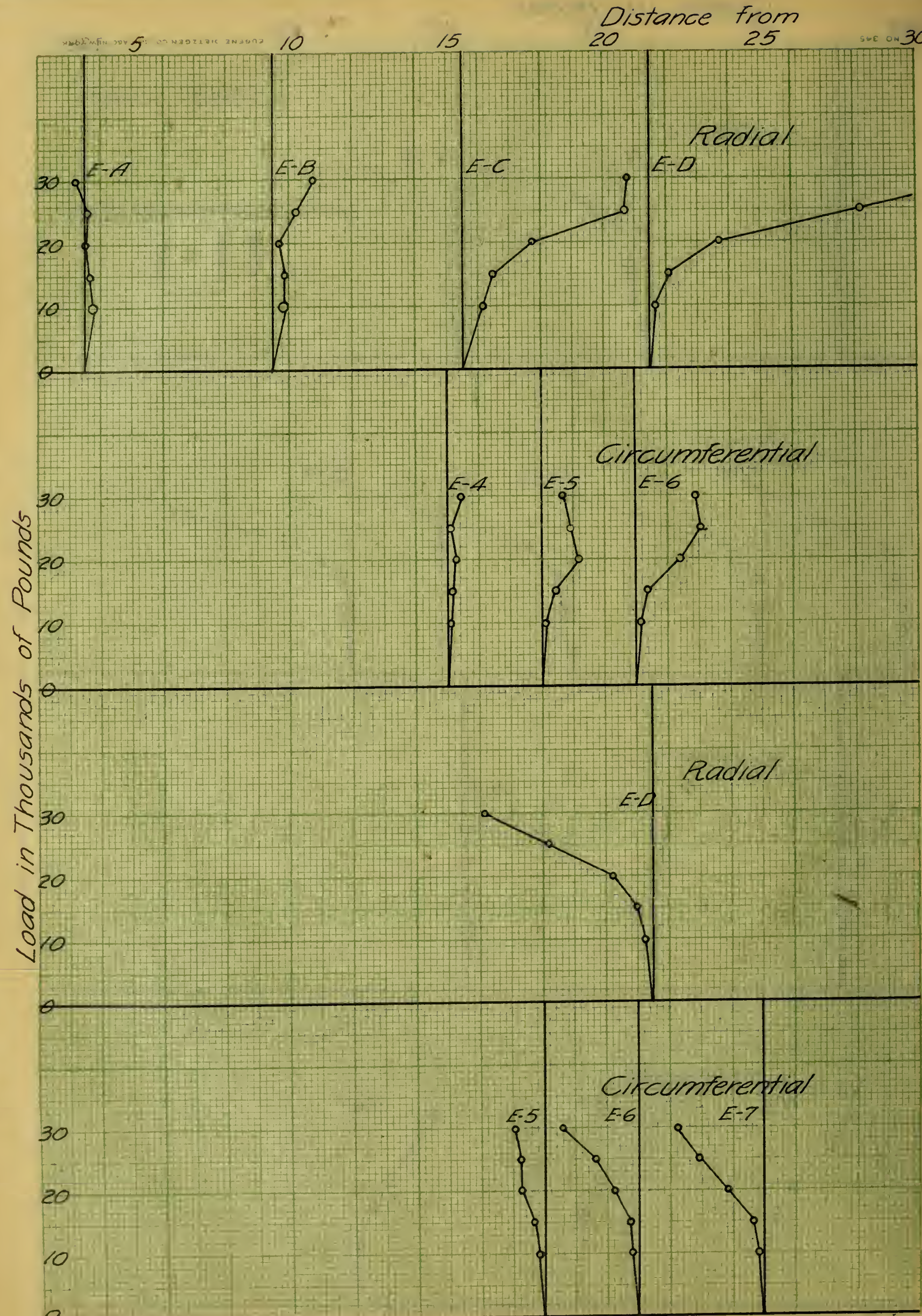


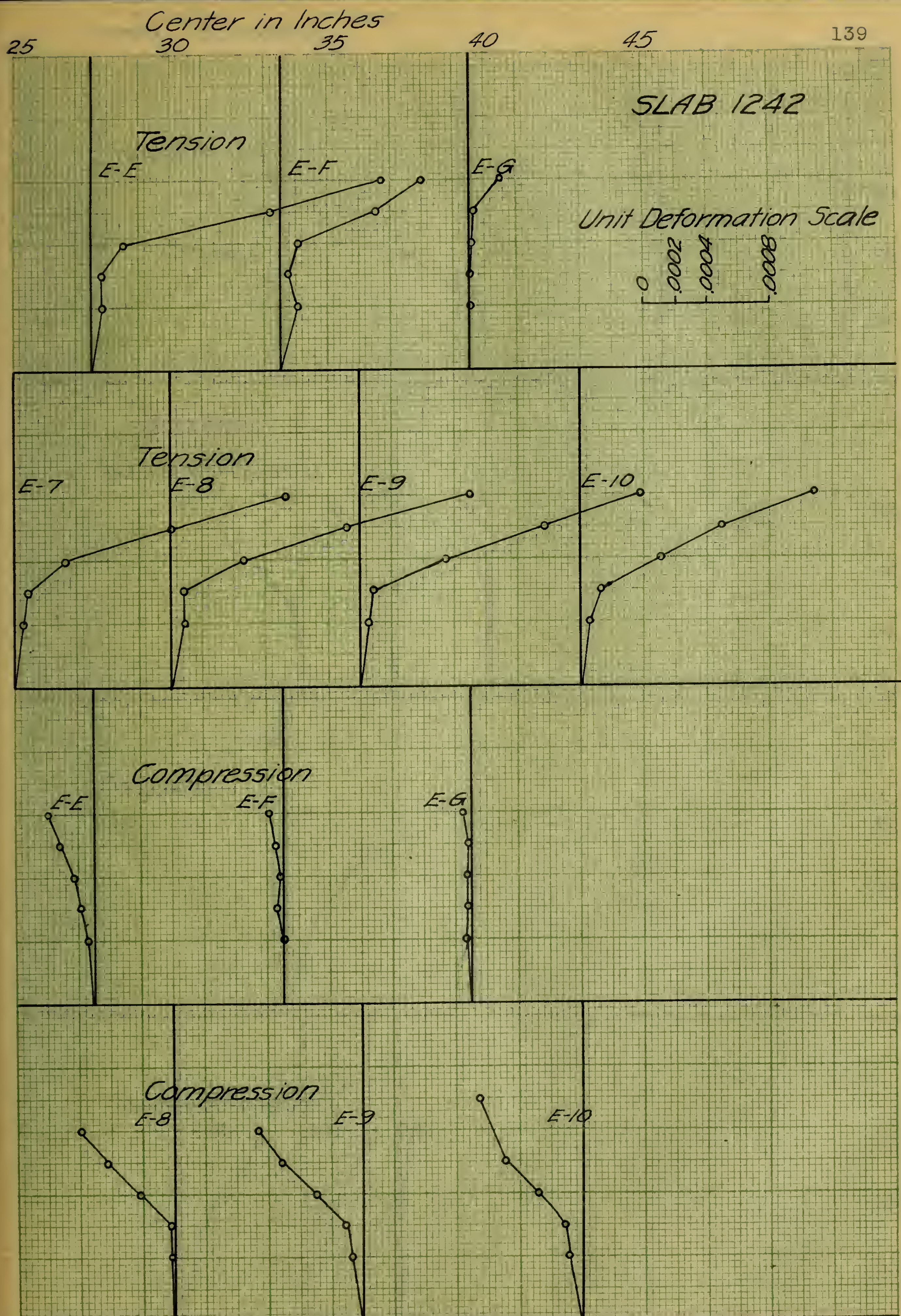
Distance from
10
15
20
25
30
Radial
N-C
N-D
Circumferential
N-4
N-5
N-6
Radial
N-D
Circumferential
N-5
N-6
N-7
Load in Thousands of Pounds
0
10
20
30

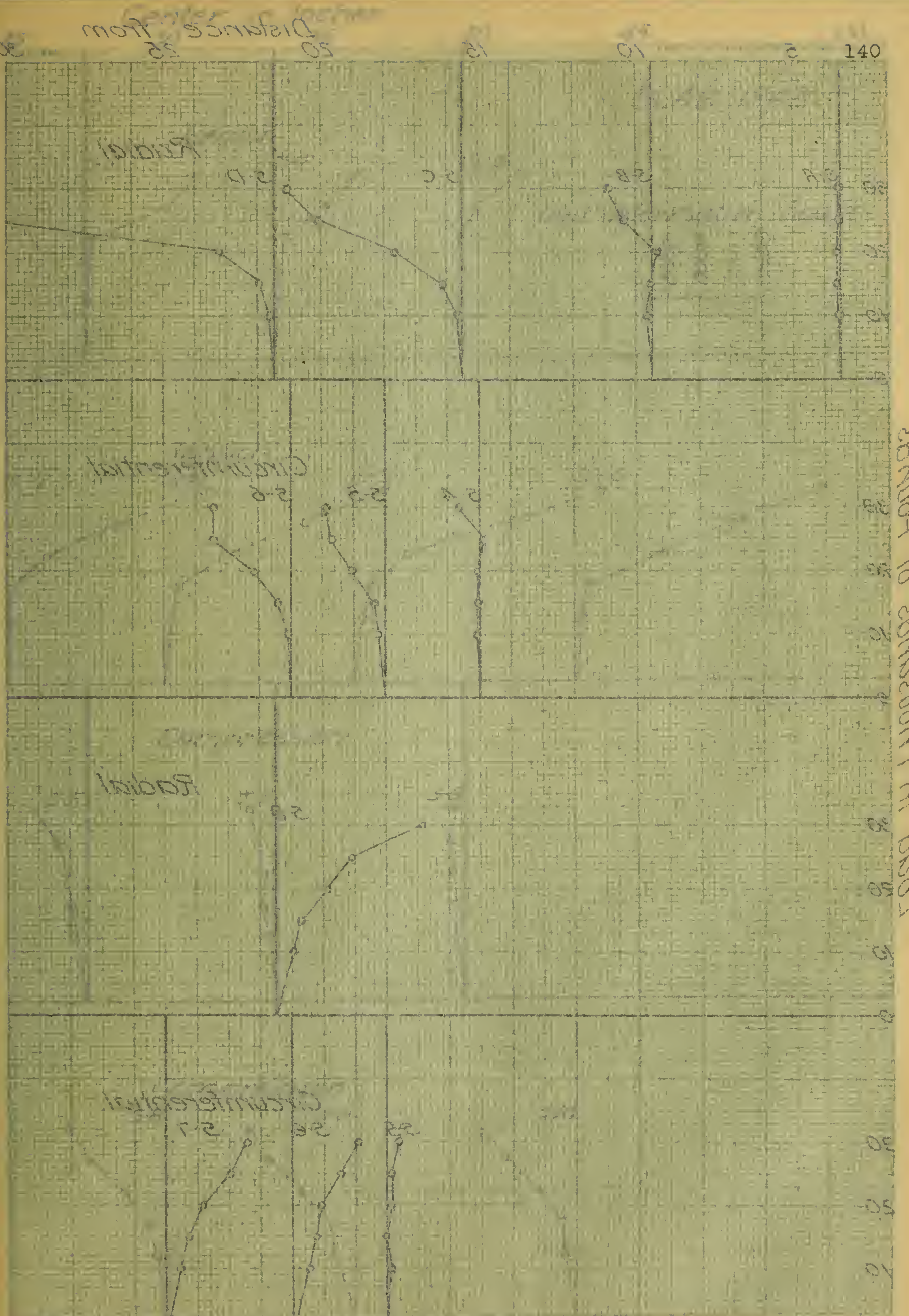

Center in Inches
25
30
35
40
45
SLAB 1242
Tension
N-F
N-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
N-7
N-8
N-9
N-10
Compression
N-E
N-F
N-G
Compression
N-8
N-9
N-10

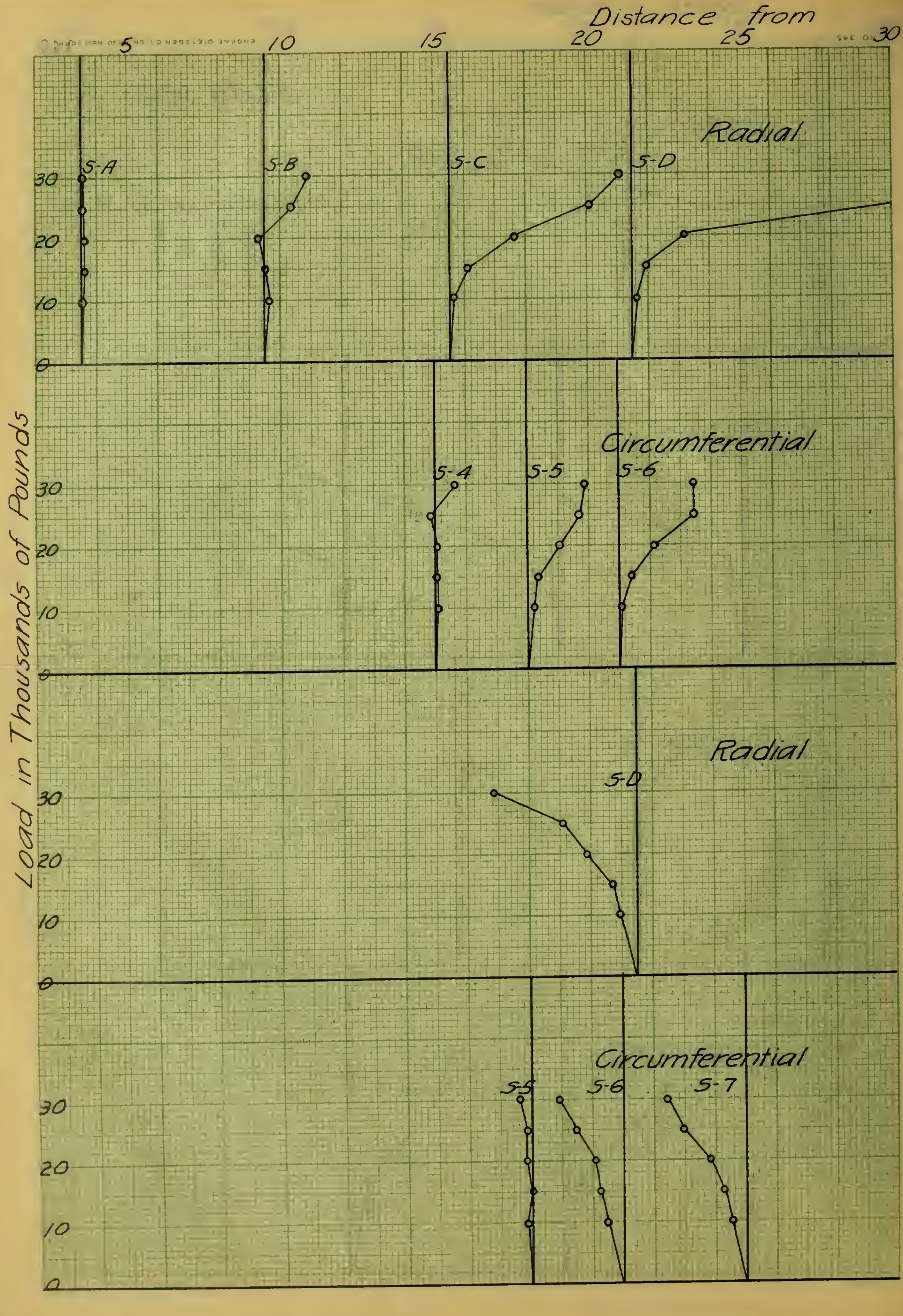


Center in Inches
25
30
35
40
45
SLAB 12-42
Unit Deformation Scale
Tension
Compression
N-7
N-8
N-9
N-10

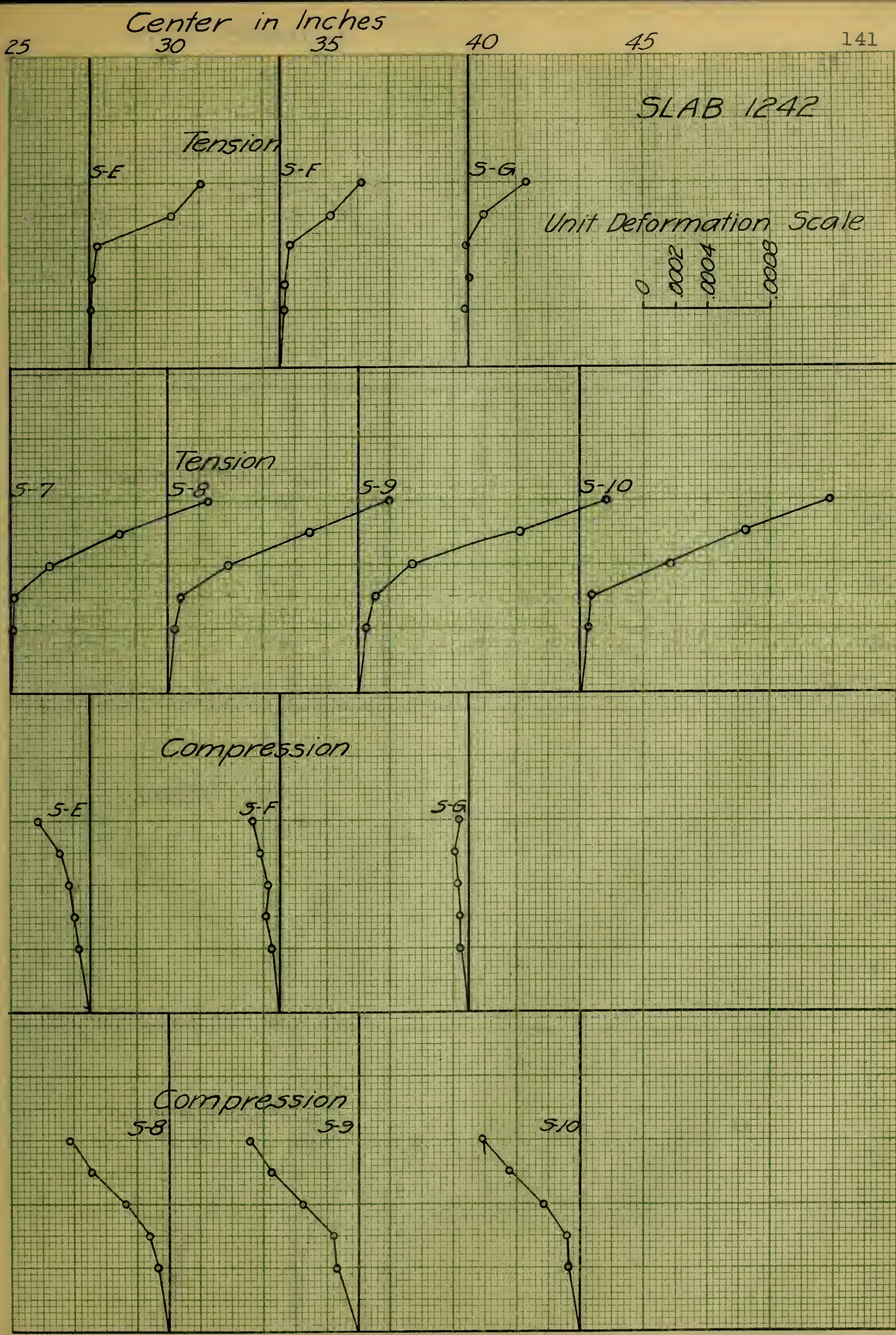

Distance from
5
10
15
20
25
30
Radial
E-A
E-B
E-C
E-D
30
20
10
0
Circumferential
E-4
E-5
E-6
Load in Thousands of Pounds
Radial
E-D
Circumferential
E-5
E-6
E-7

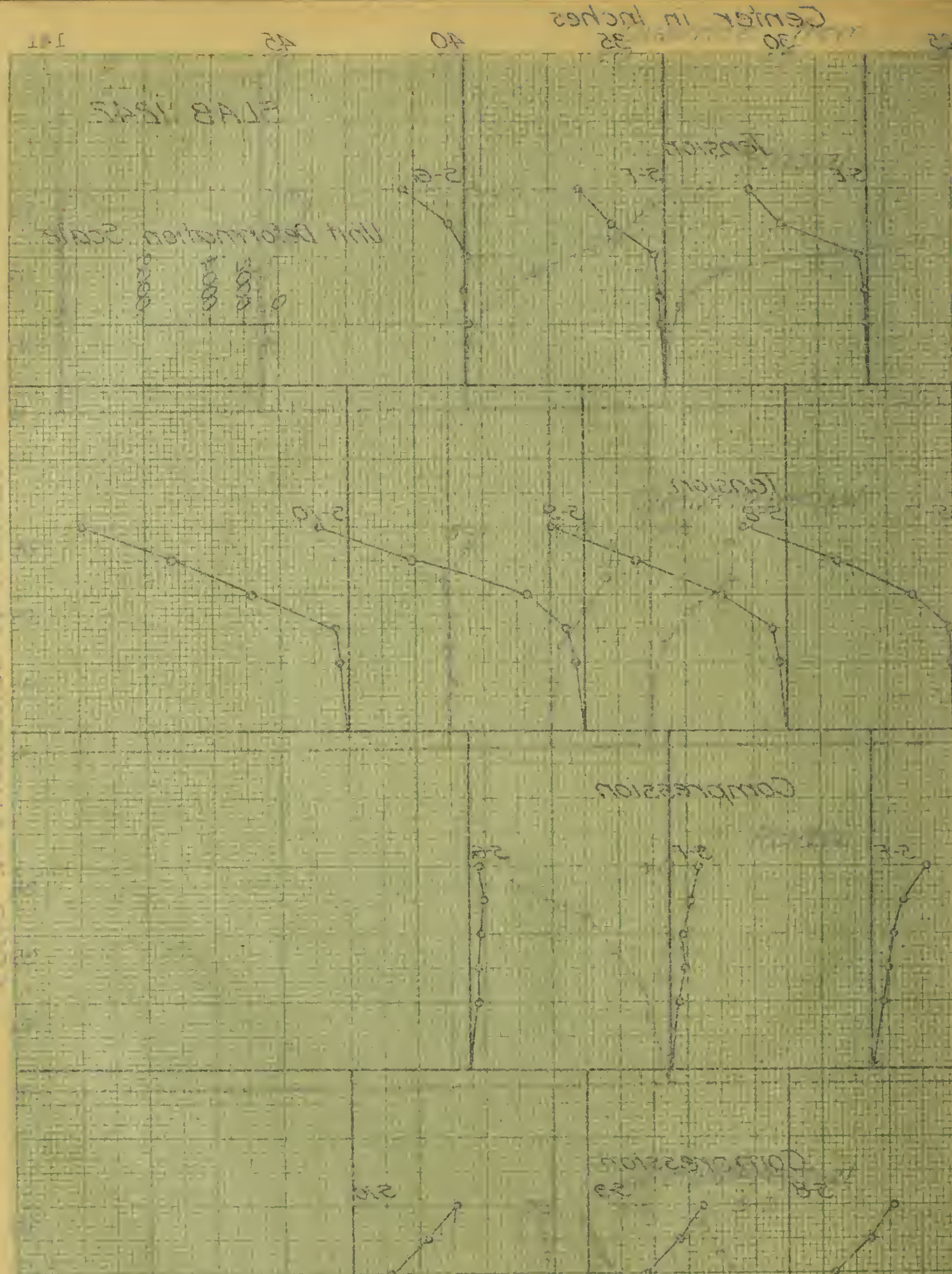

Center in Inches
25
30
35
40
45
SLAB 1242
Tension
E-E
E-F
E-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E-7
E-8
E-9
E-10
Compression
E-E
E-F
E-G
Compression
E-8
E-9
E-10


Distance from
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

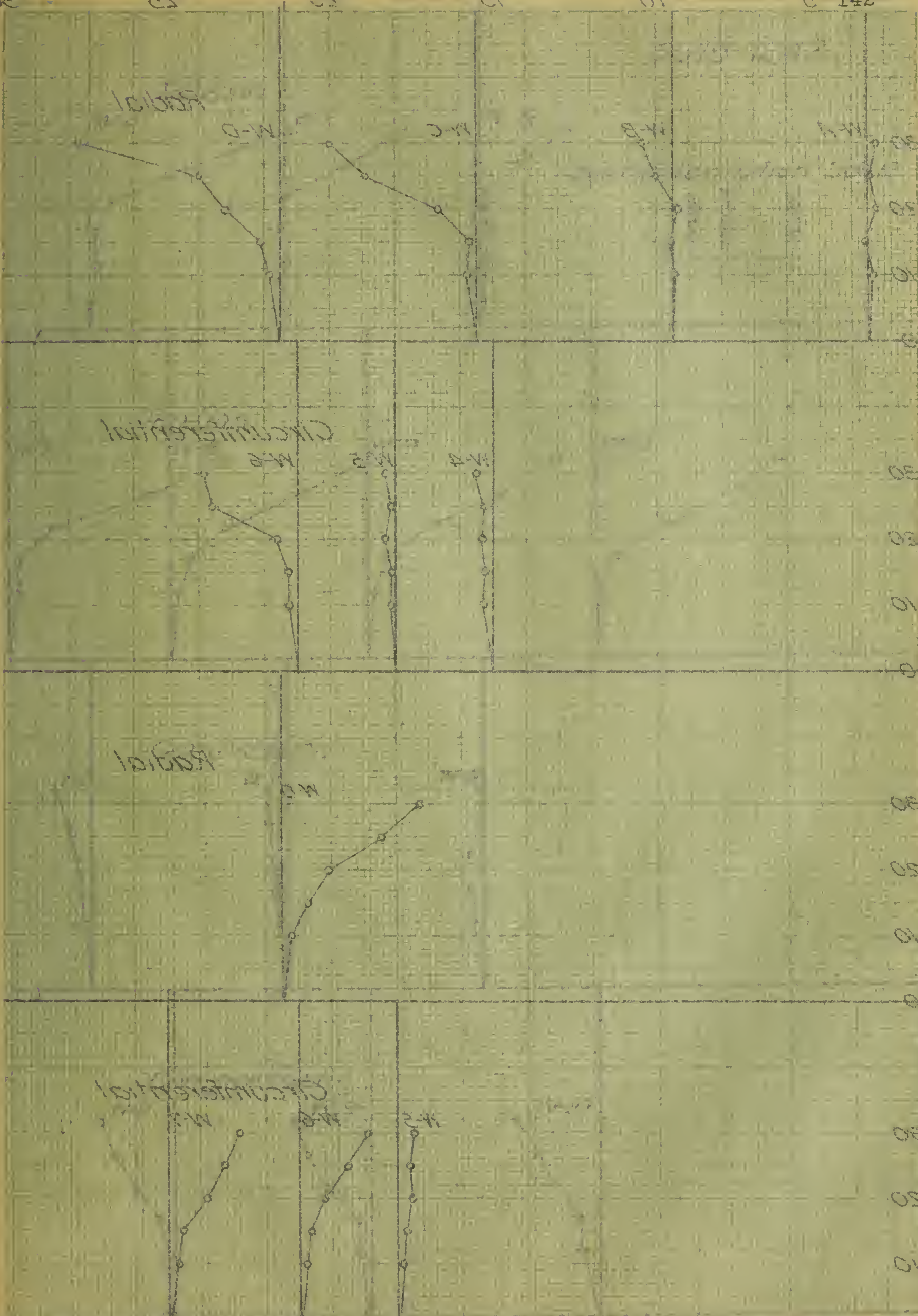


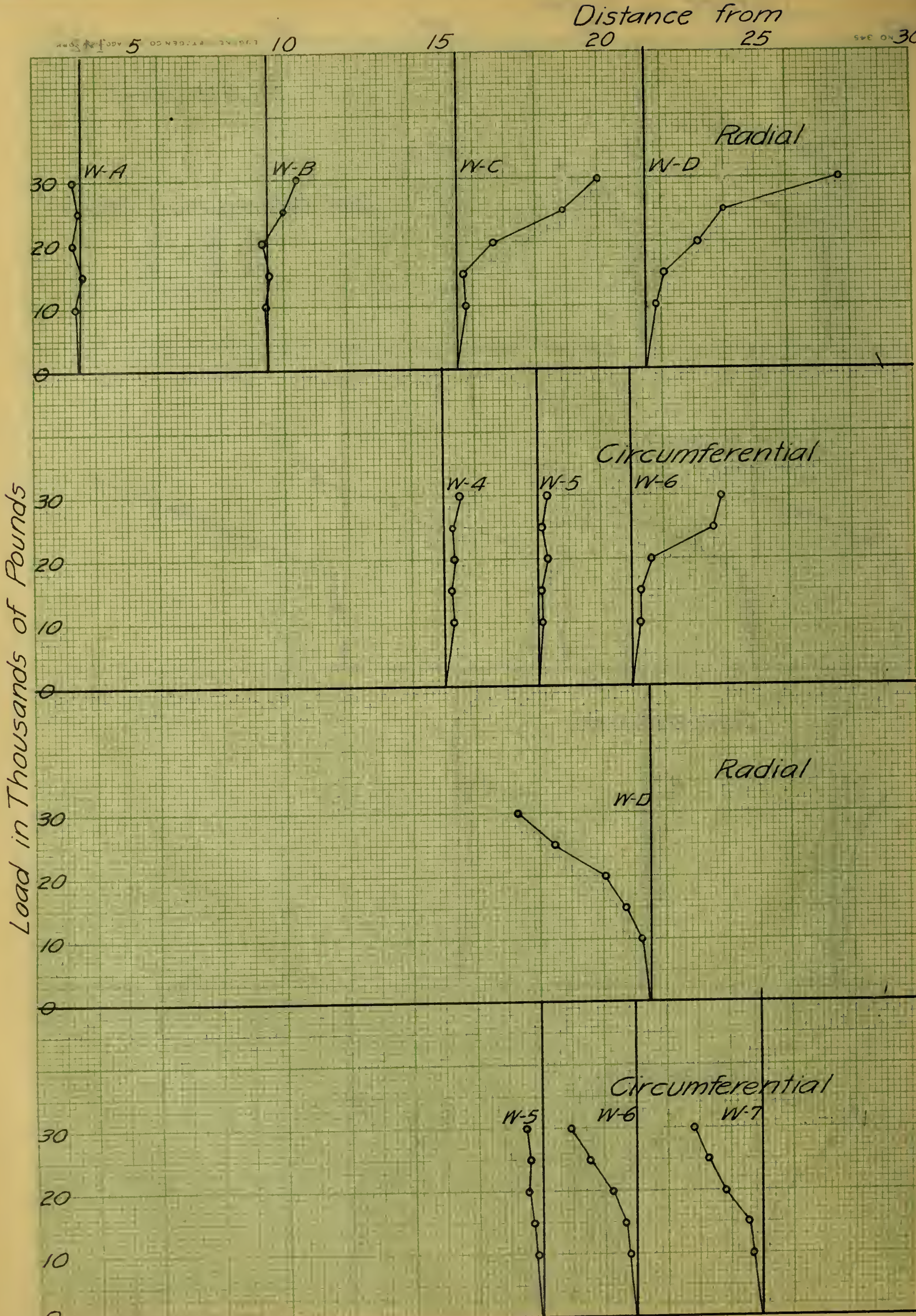
Distance from
5
10
15
20
25
30
Load in Thousands of Pounds
Radial
S-A
S-B
S-C
S-D
Circumferential
S-4
S-5
S-6
Radial
S-D
Circumferential
S-5
S-6
S-7
0
10
20
30

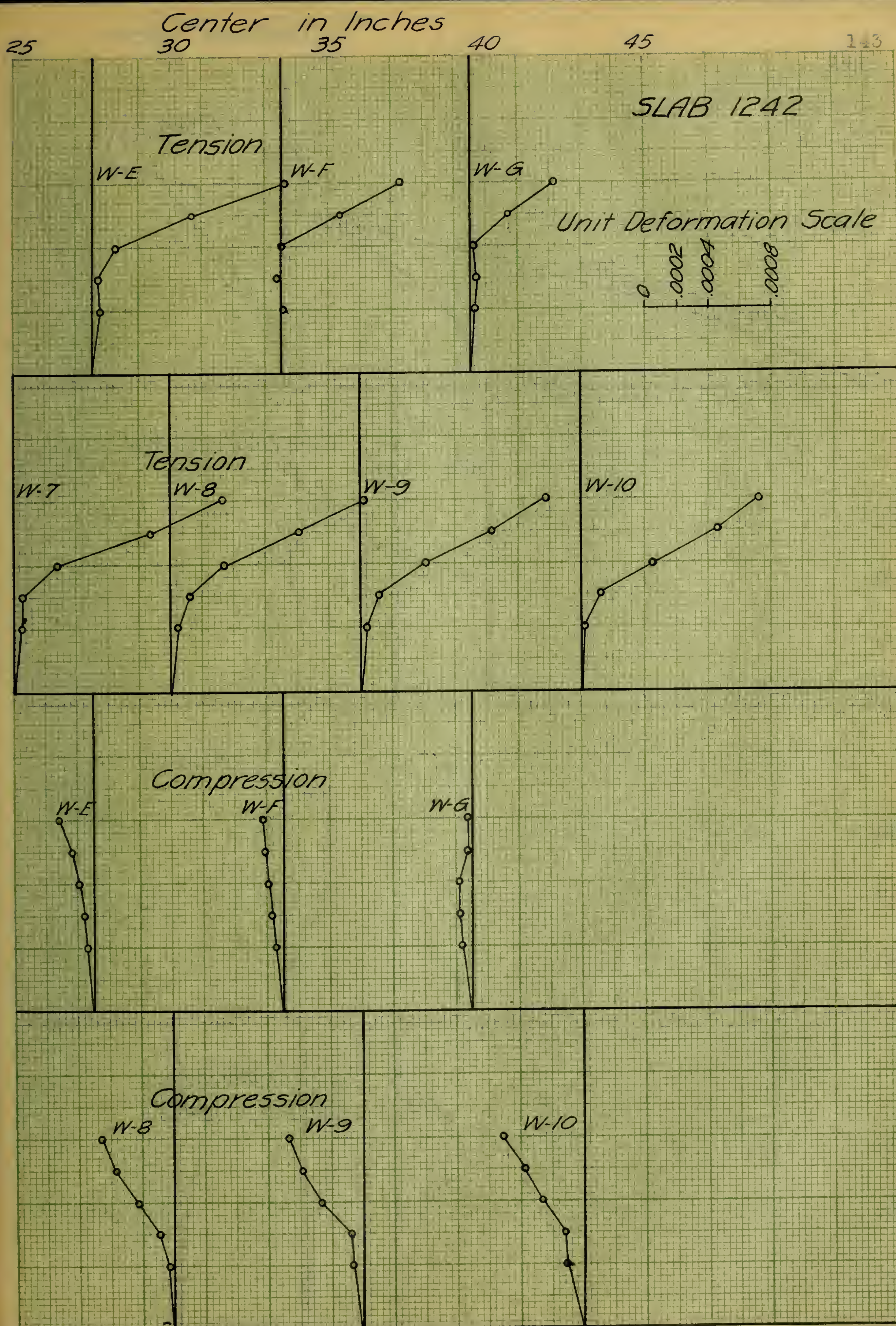

Center in Inches
25
30
35
40
45
SLAB 1242
Tension
S-E
S-F
S-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
S-7
S-8
S-9
S-10
Compression
S-E
S-F
S-G
Compression
S-8
S-9
S-10
NO 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK

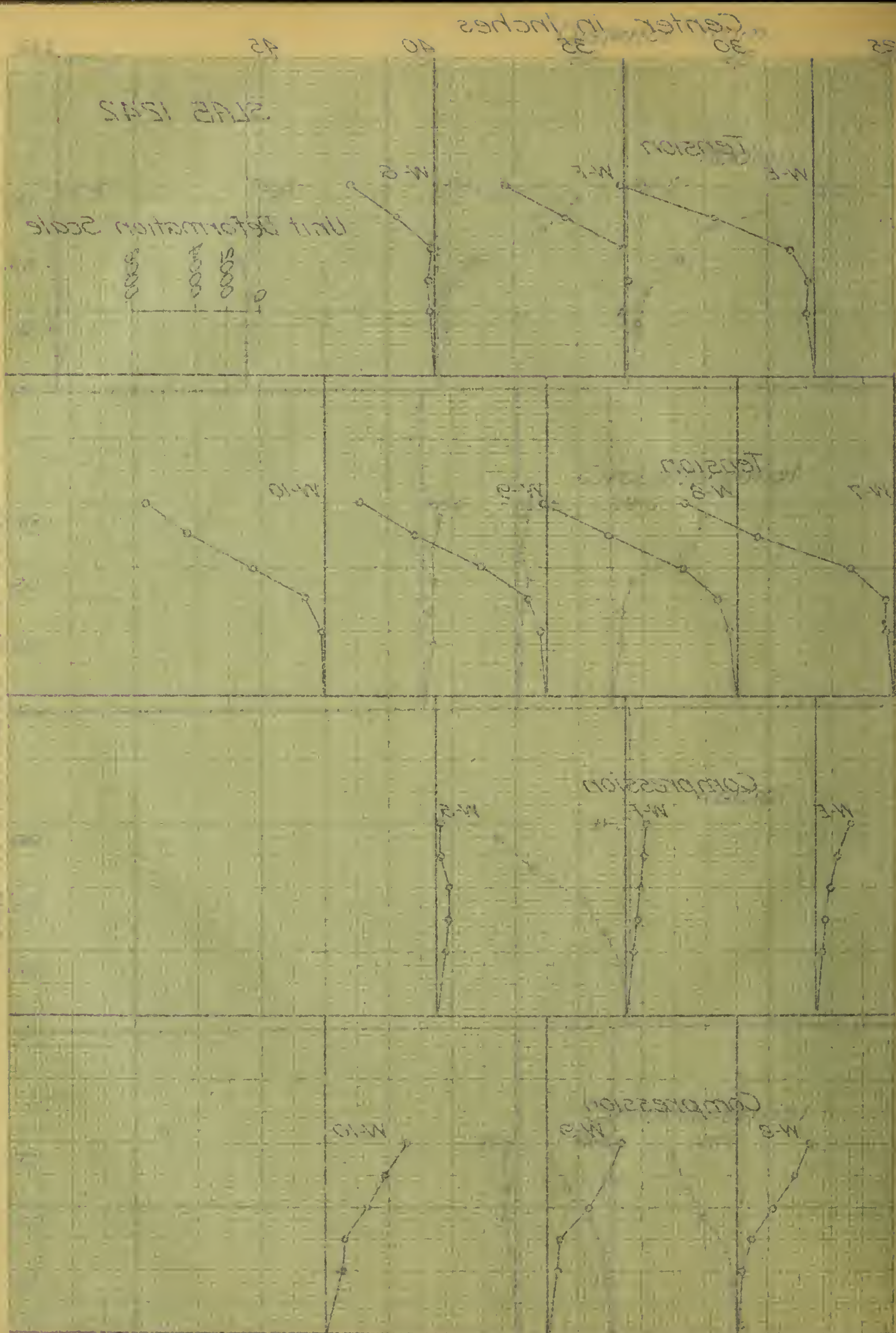


Center in inches
25
30
35
40
45
Tension
Unit Deformation Scale
Compression

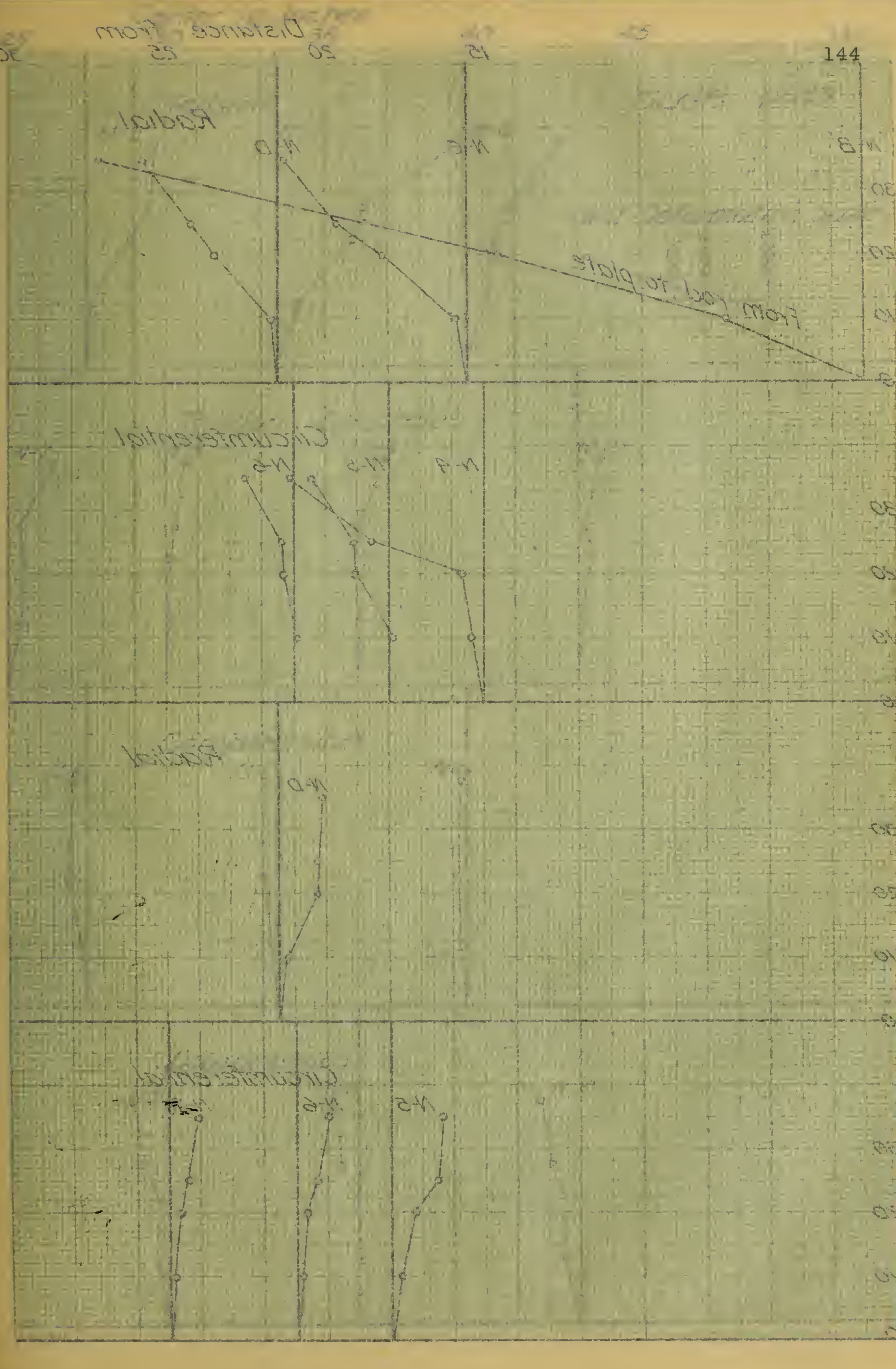


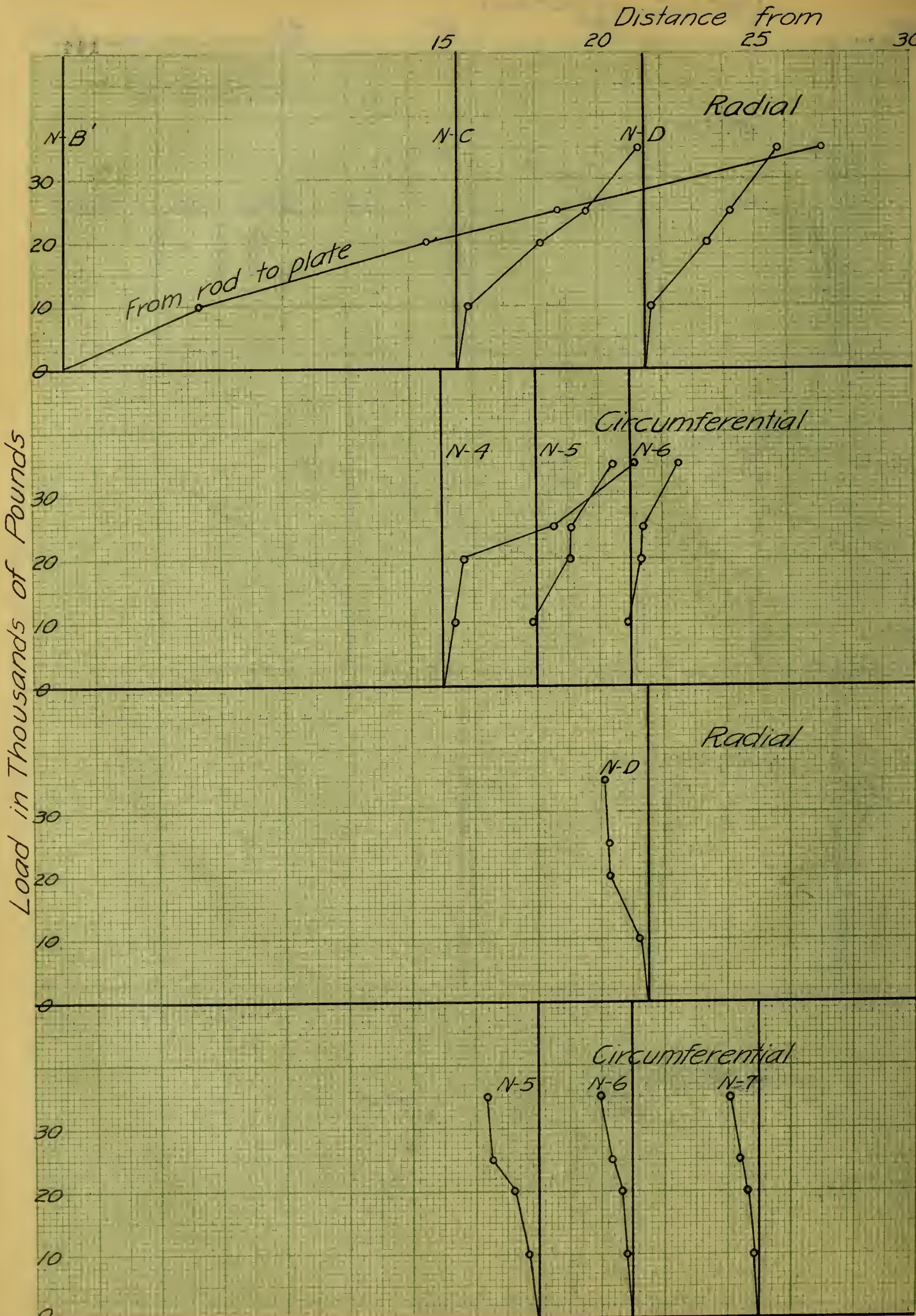

Distance from
5
10
15
20
25
30
Load in Thousands of Pounds
Radial
W-A
W-B
W-C
W-D
Circumferential
W-4
W-5
W-6
Radial
W-D
Circumferential
W-5
W-6
W-7
0
10
20
30


Center in Inches
25
30
35
40
45
SLAB 1242
Tension
W-E
W-F
W-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
W-7
W-8
W-9
W-10
Compression
W-E
W-F
W-G
Compression
W-8
W-9
W-10

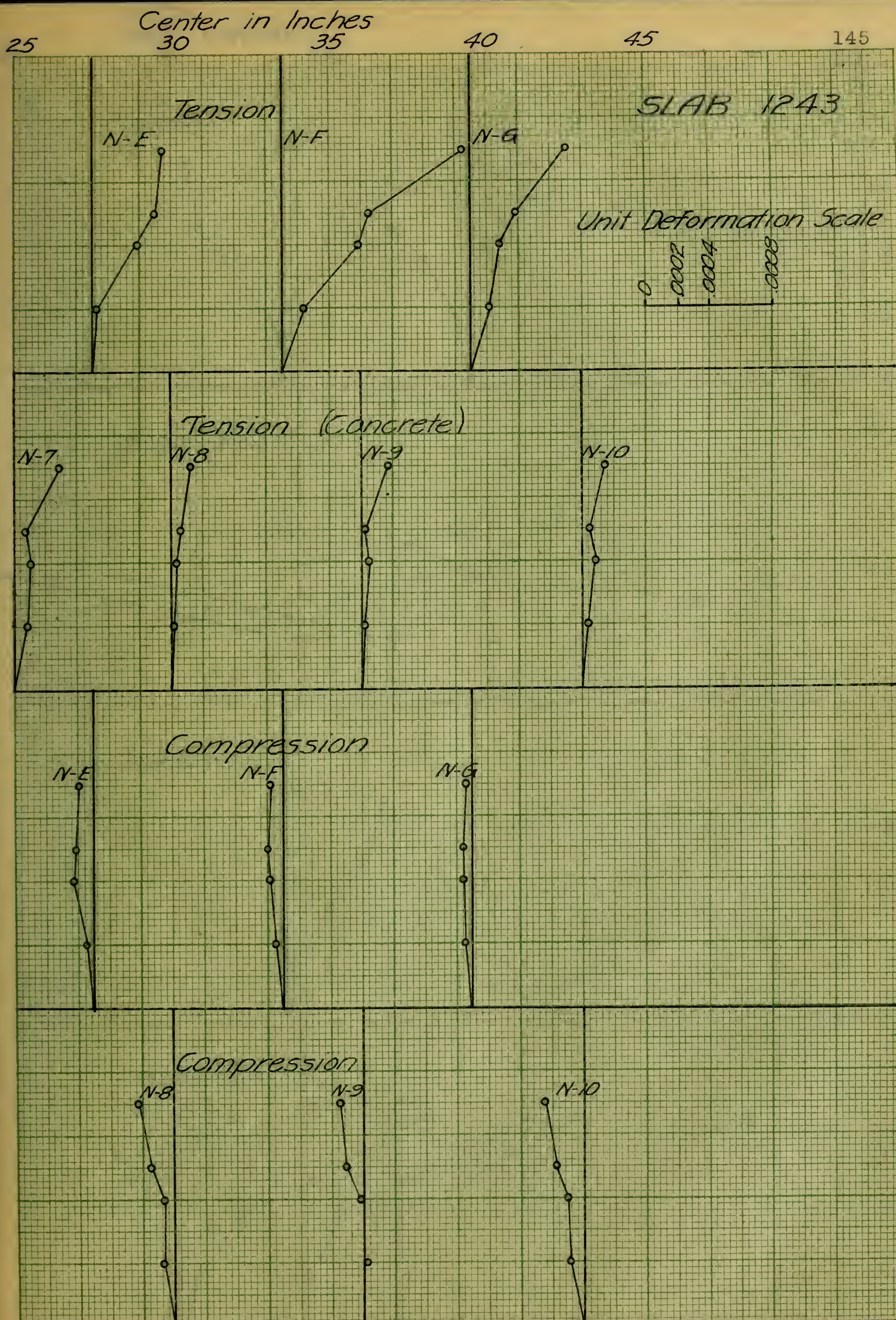


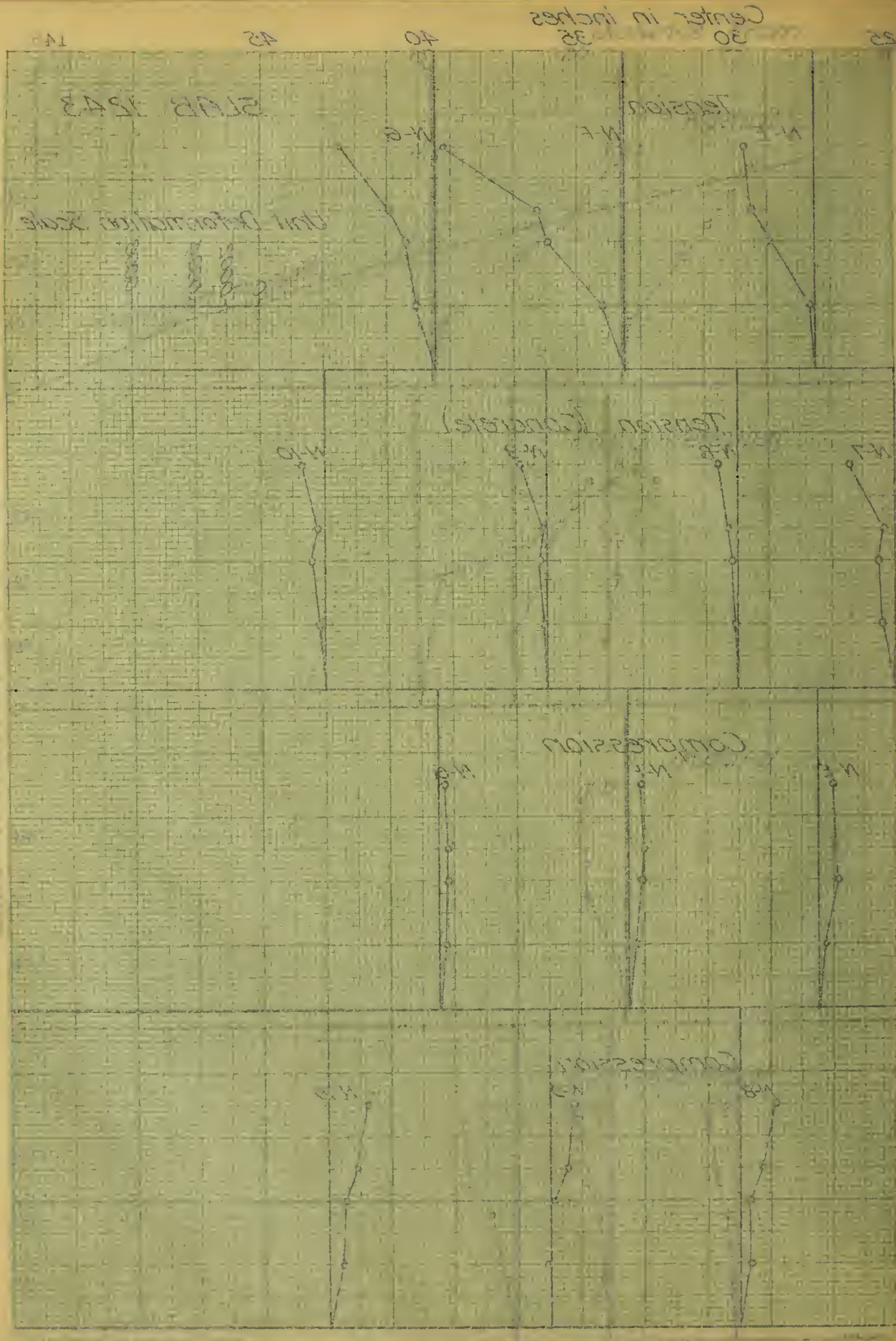
Slab 1242
Center in inches
Unit Deformation Scale
Tension
Compression
W-5
W-4
W-6
W-10
W-9
W-8
W-7


Distance From
Radial
From rod to plate
Circumferential
Radial
Circumferential
Load in Thousands of Pounds

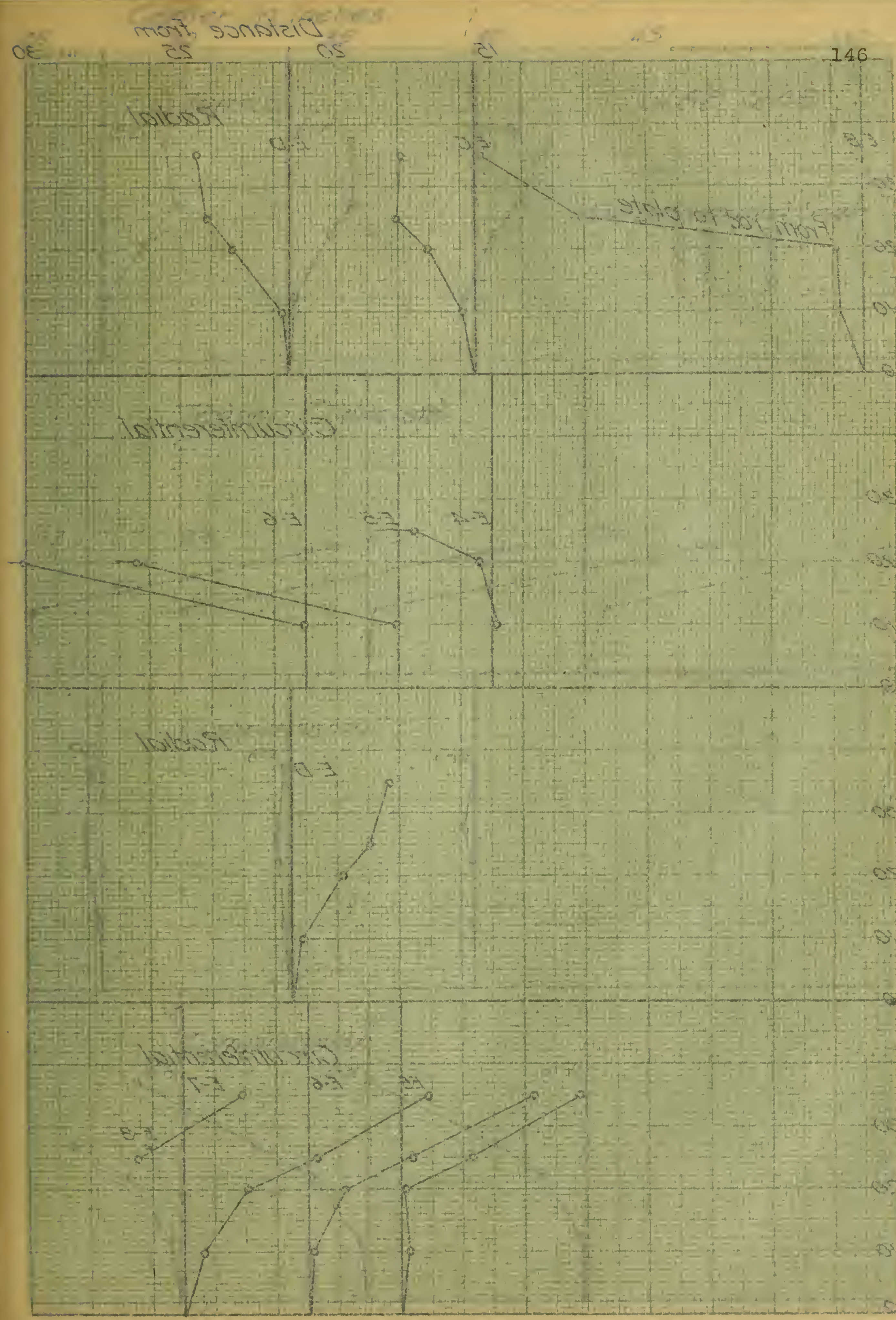


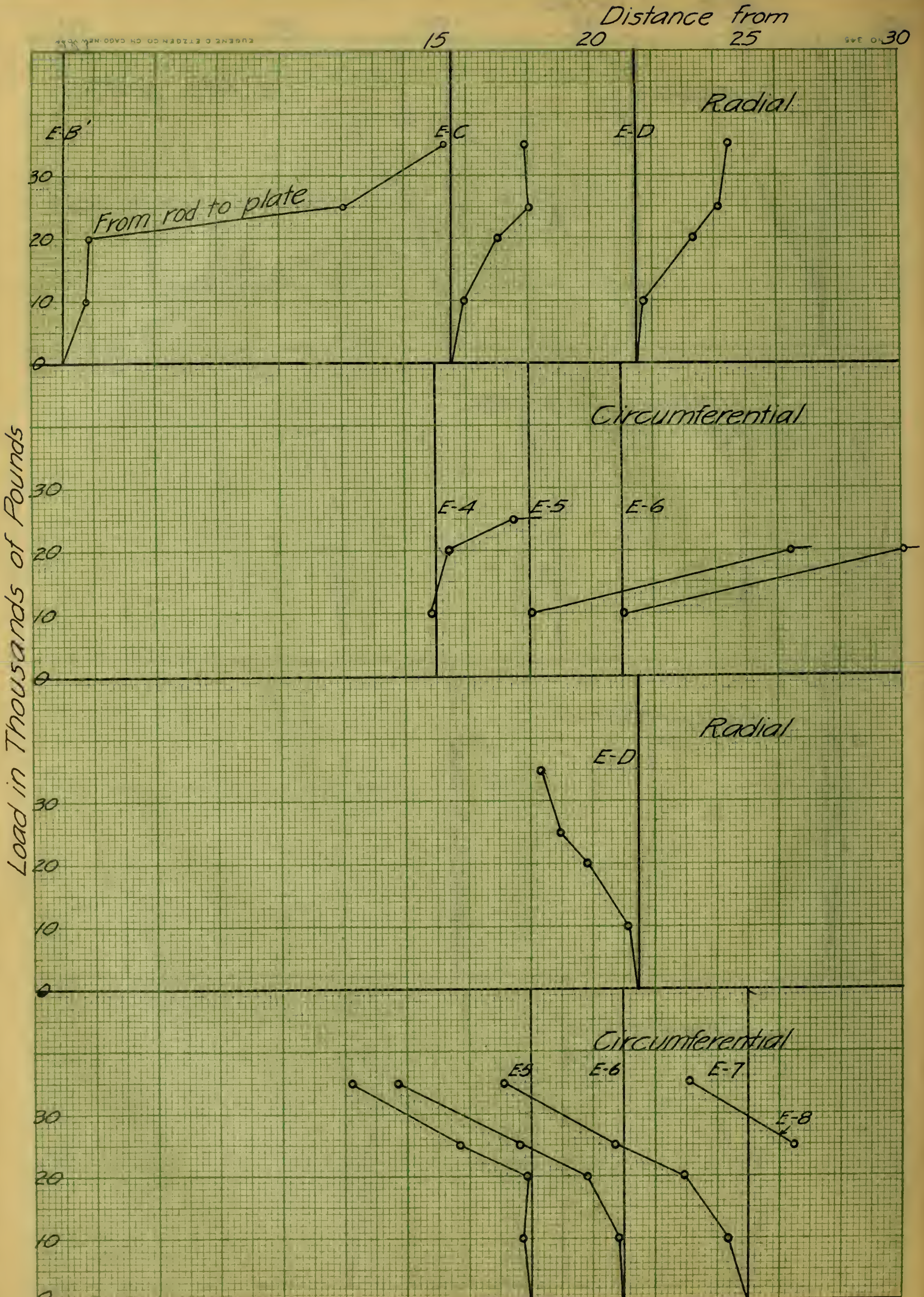
Distance from
15
20
25
30
Radial
N-B'
N-C
N-D
From rod to plate
0
10
20
30
Circumferential
N-4
N-5
N-6
Radial
N-D
Circumferential
N-5
N-6
N-7
Load in Thousands of Pounds


Center in Inches
25
30
35
40
45
SLAB 1243
Tension
N-E
N-F
N-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension (Concrete)
N-7
N-8
N-9
N-10
Compression
N-E
N-F
N-G
Compression
N-8
N-9
N-10

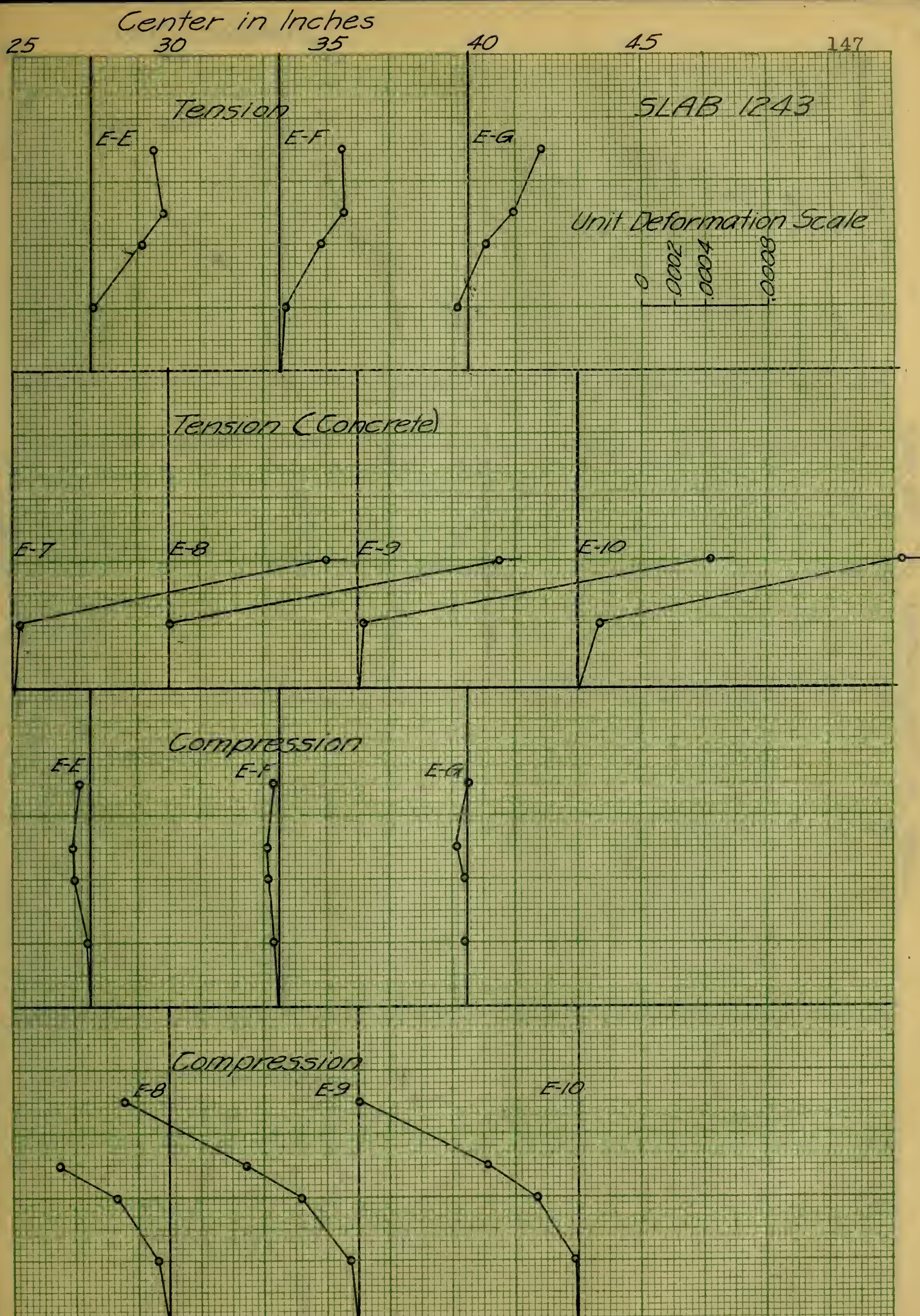


Center in inches
25
30
35
40
45
SLAB 1243
Unit Deformation Scale
Tension
Tension (Concrete)
Compression
Compression
Load in Thousands of Pounds


Distance from
30
25
20
15
Radial
Circumferential
From rod to plate
E-4
E-5
E-6
E-7
Load in Thousands of Pounds

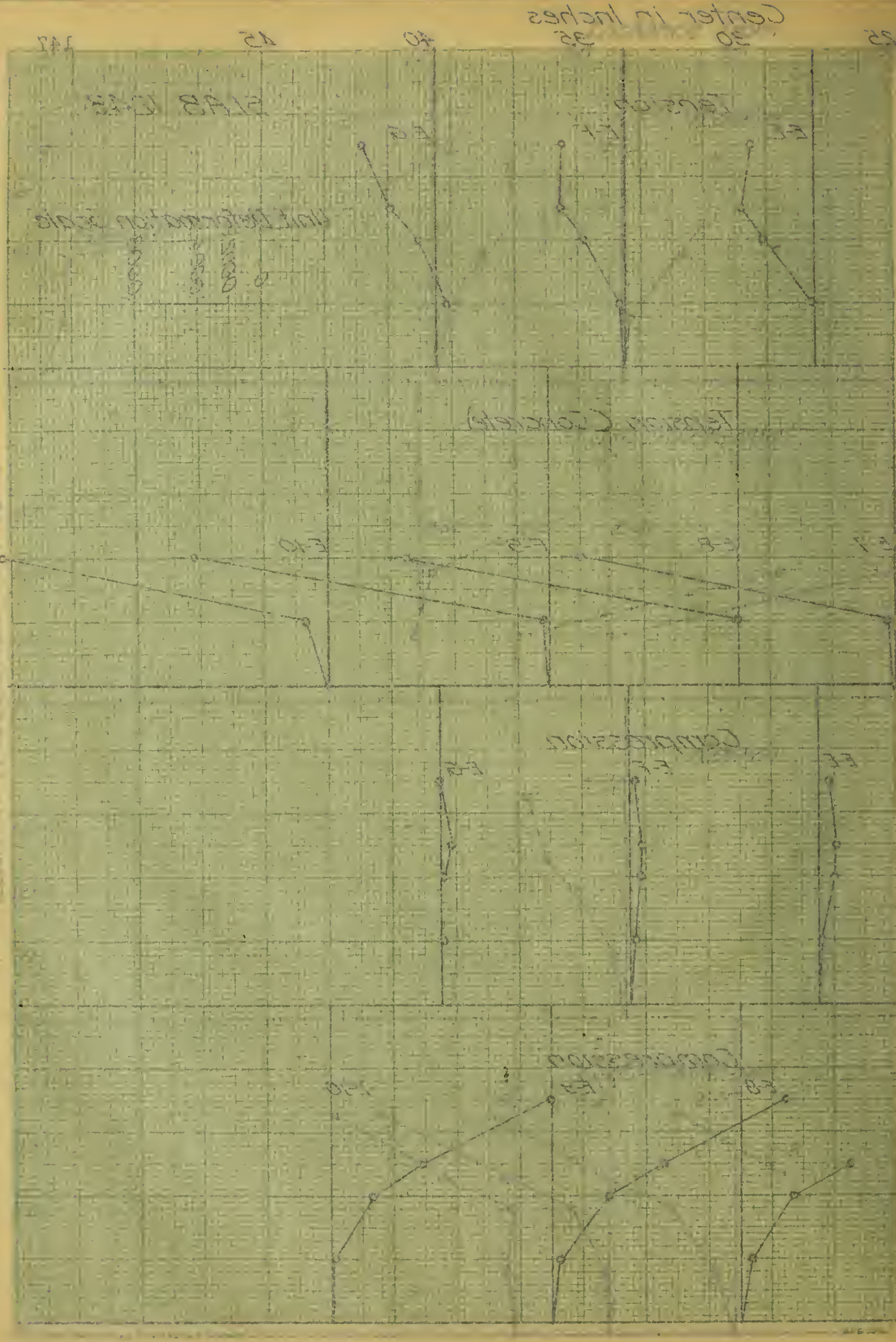


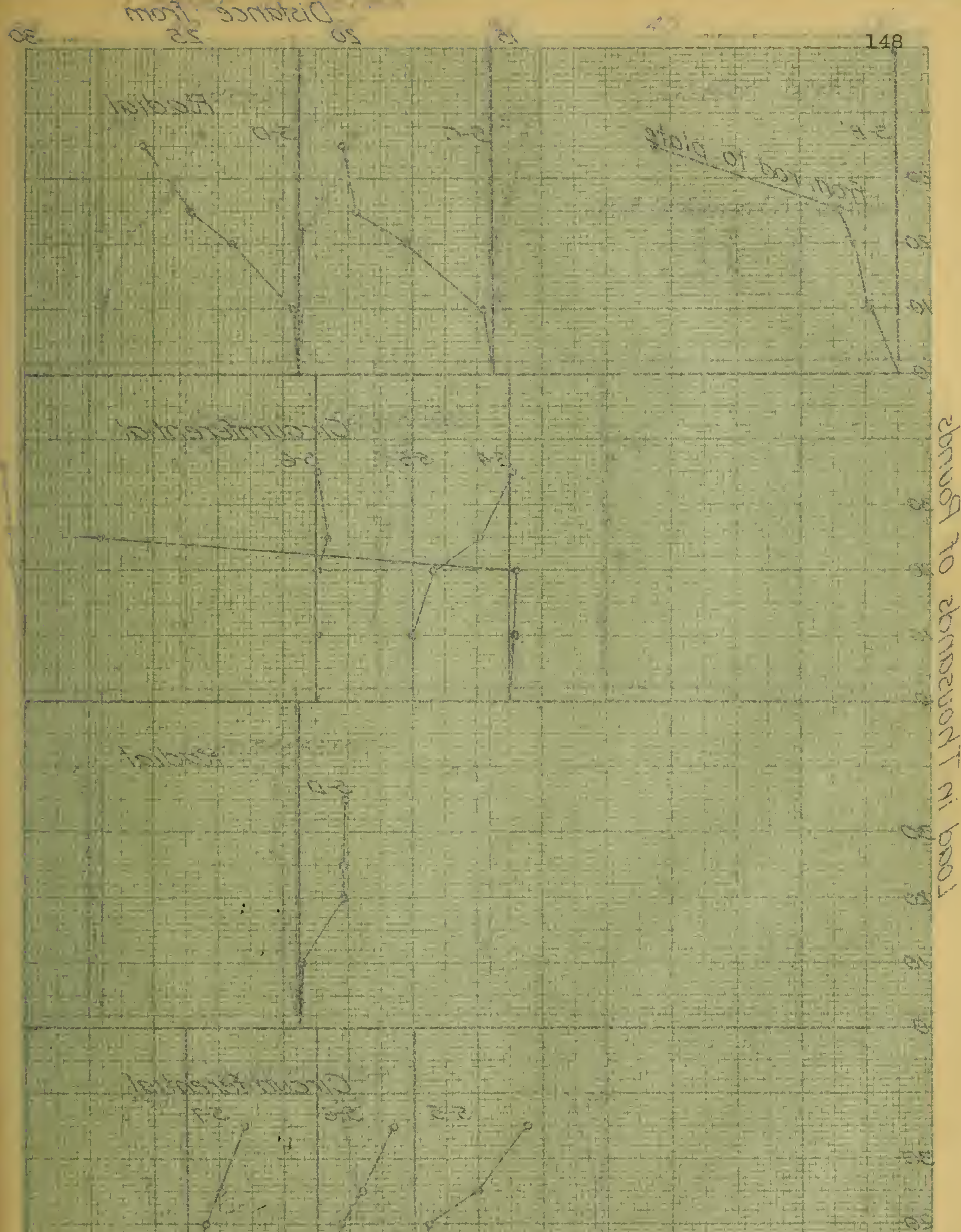
Distance from
15
20
25
30
Radial
E-B'
E-C
E-D
From rod to plate
30
20
10
0
Circumferential
E-4
E-5
E-6
Radial
E-D
Circumferential
E-5
E-6
E-7
E-8
Load in Thousands of Pounds

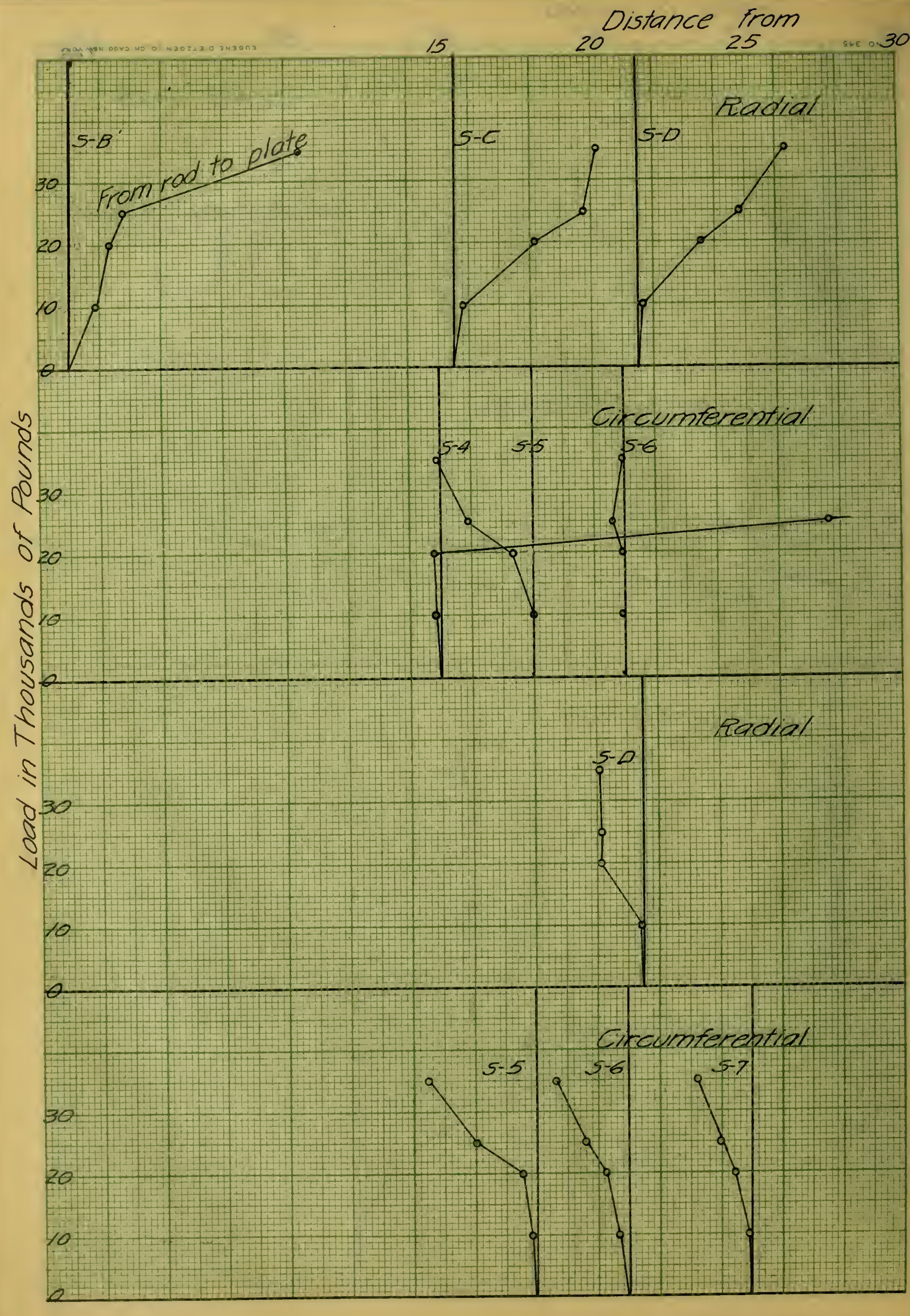


NO. 345

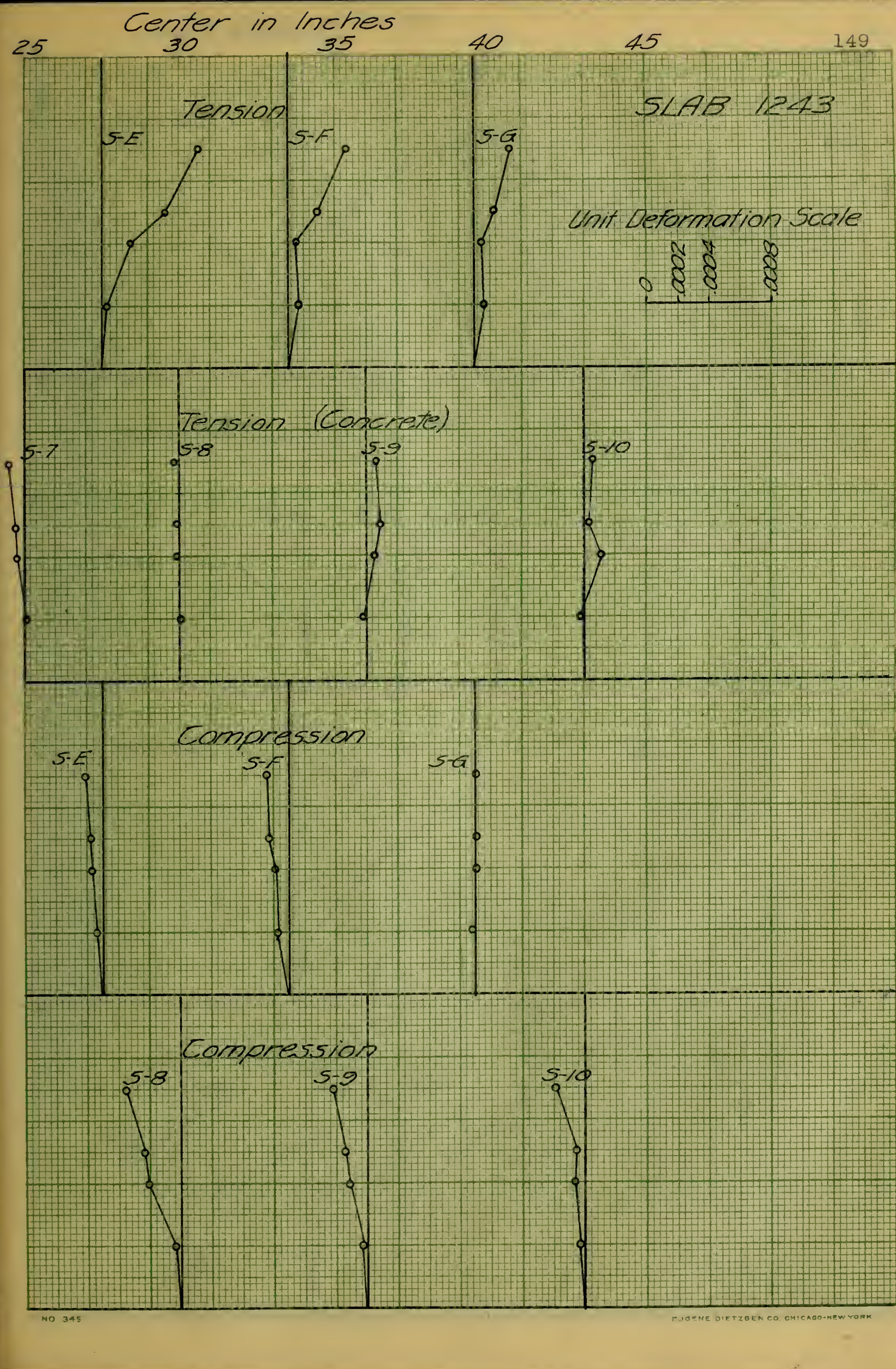
EUGENE DIETZGEN CO. CHICAGO-NEW YORK

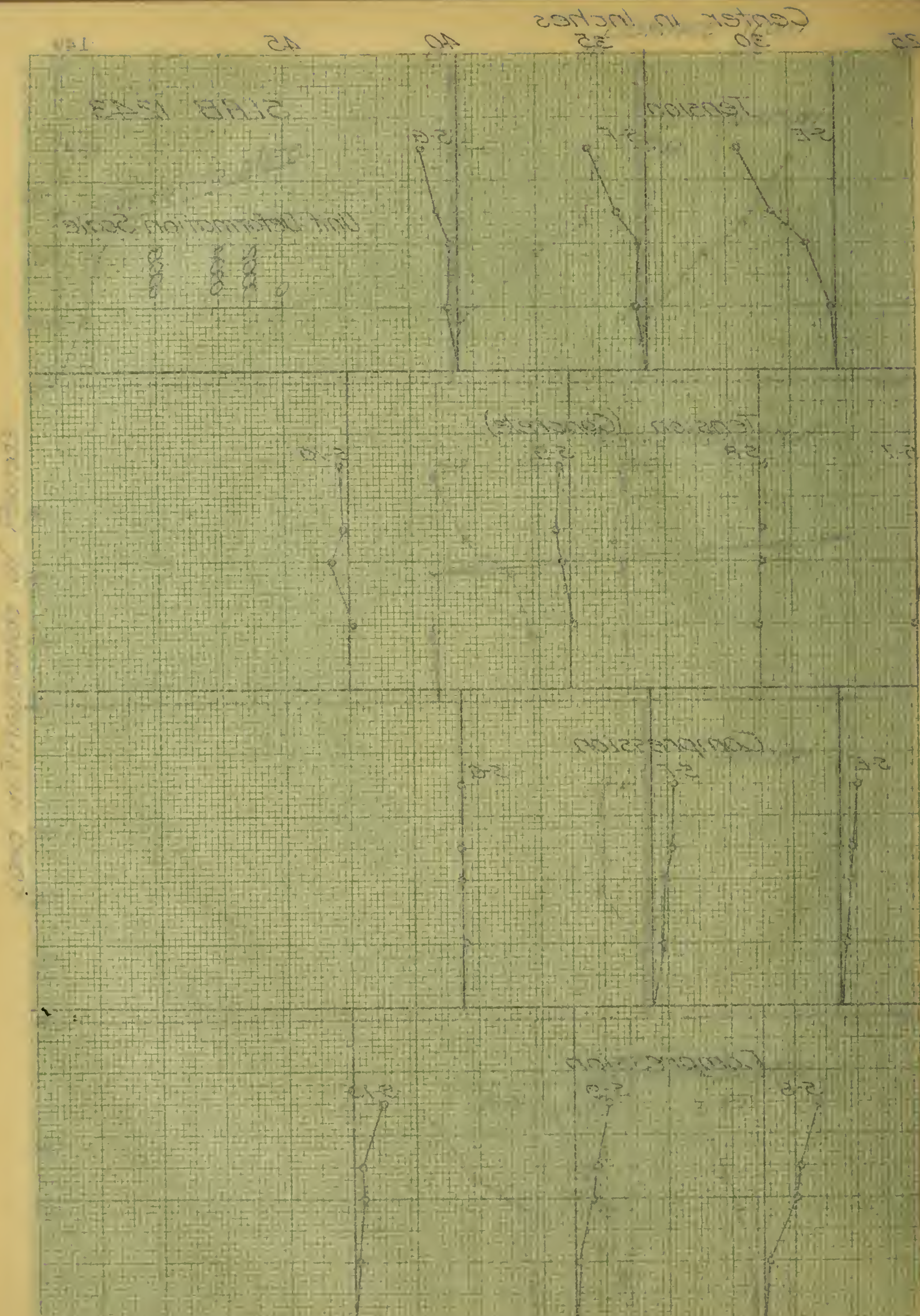

Center in Inches
25
30
35
40
45

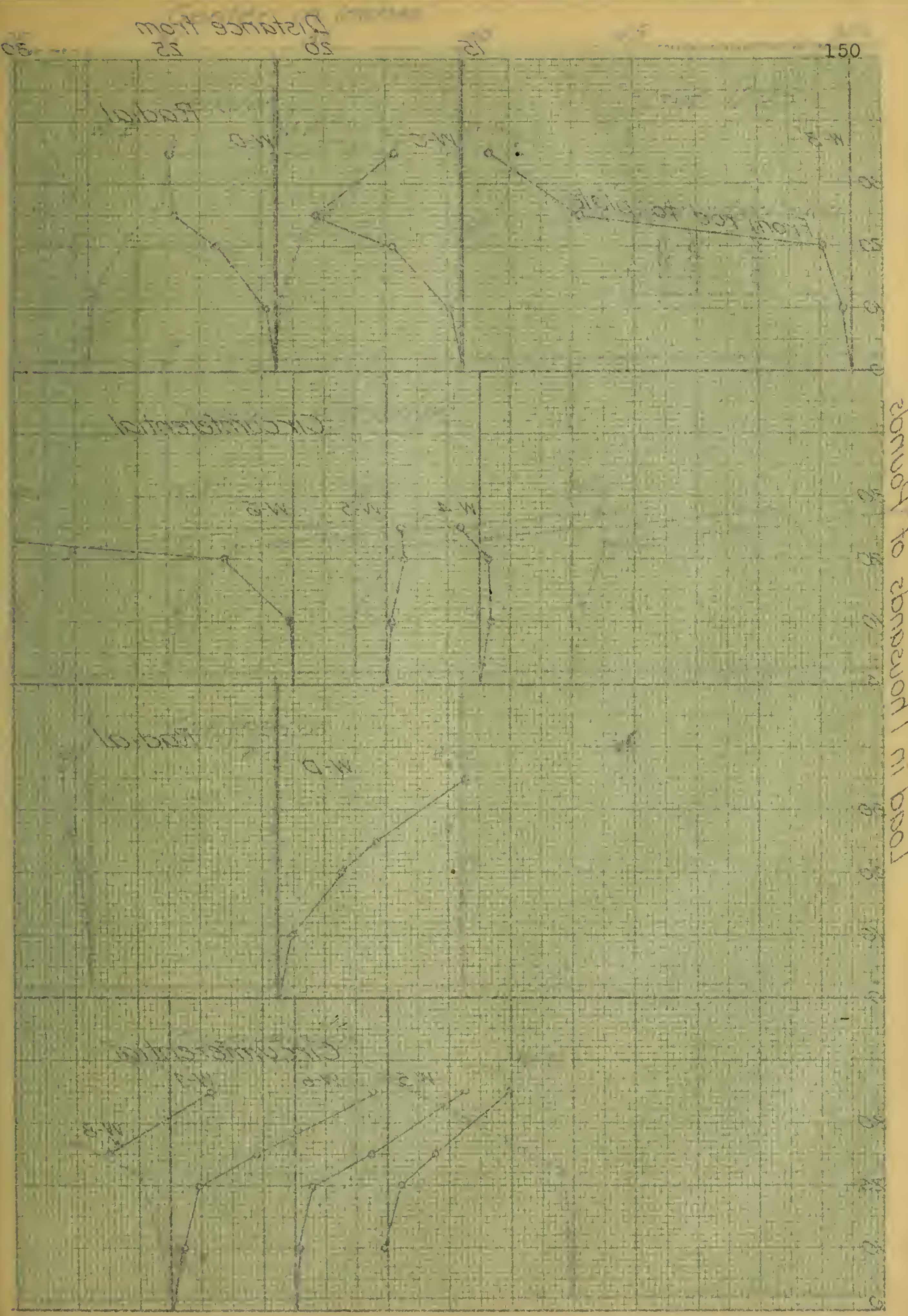


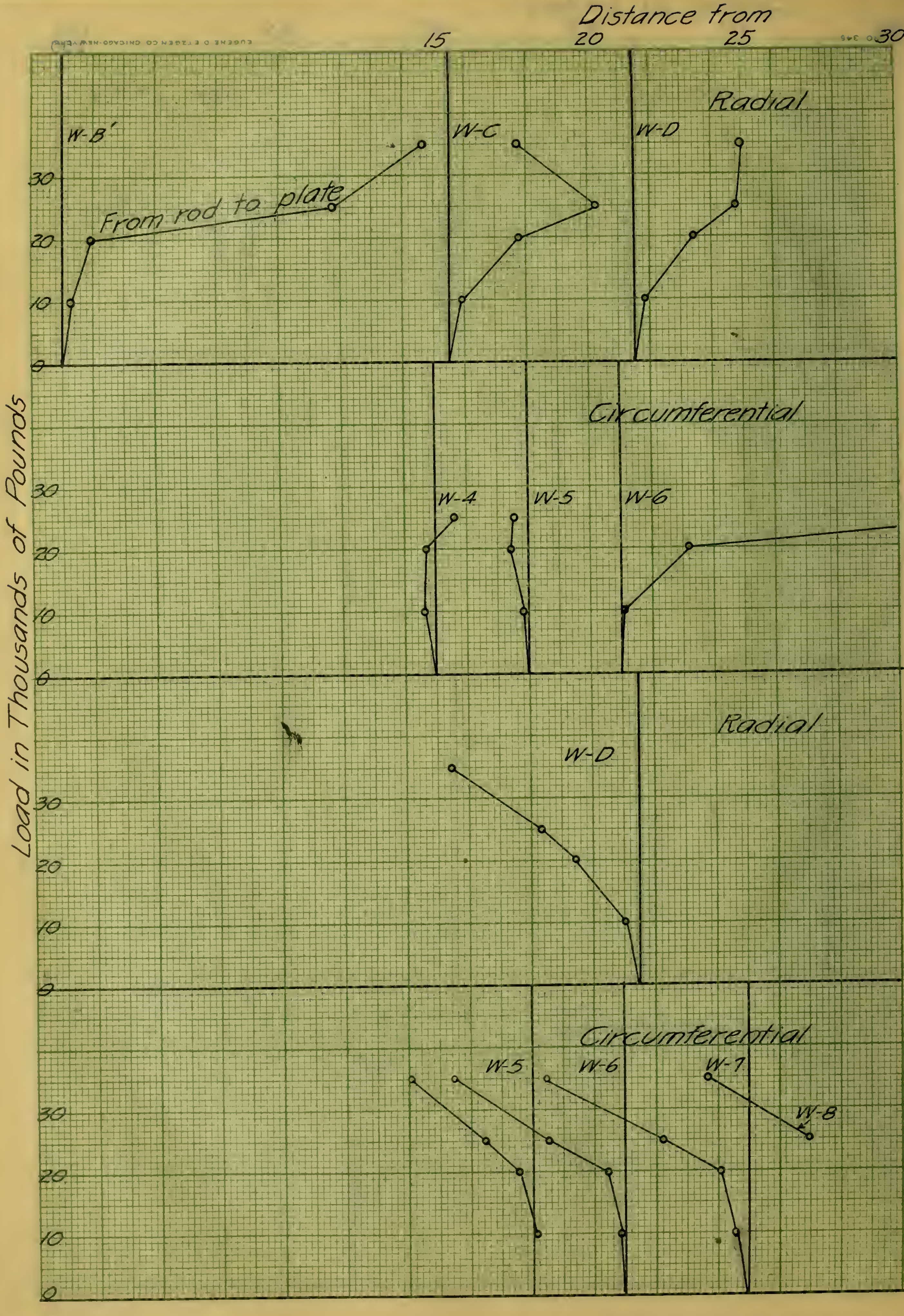


Distance from
15
20
25
30
Radial
5-B
From rod to plate
5-C
5-D
Load in Thousands of Pounds
0
10
20
30
Circumferential
5-4
5-5
5-6
Radial
5-D
Circumferential
5-5
5-6
5-7

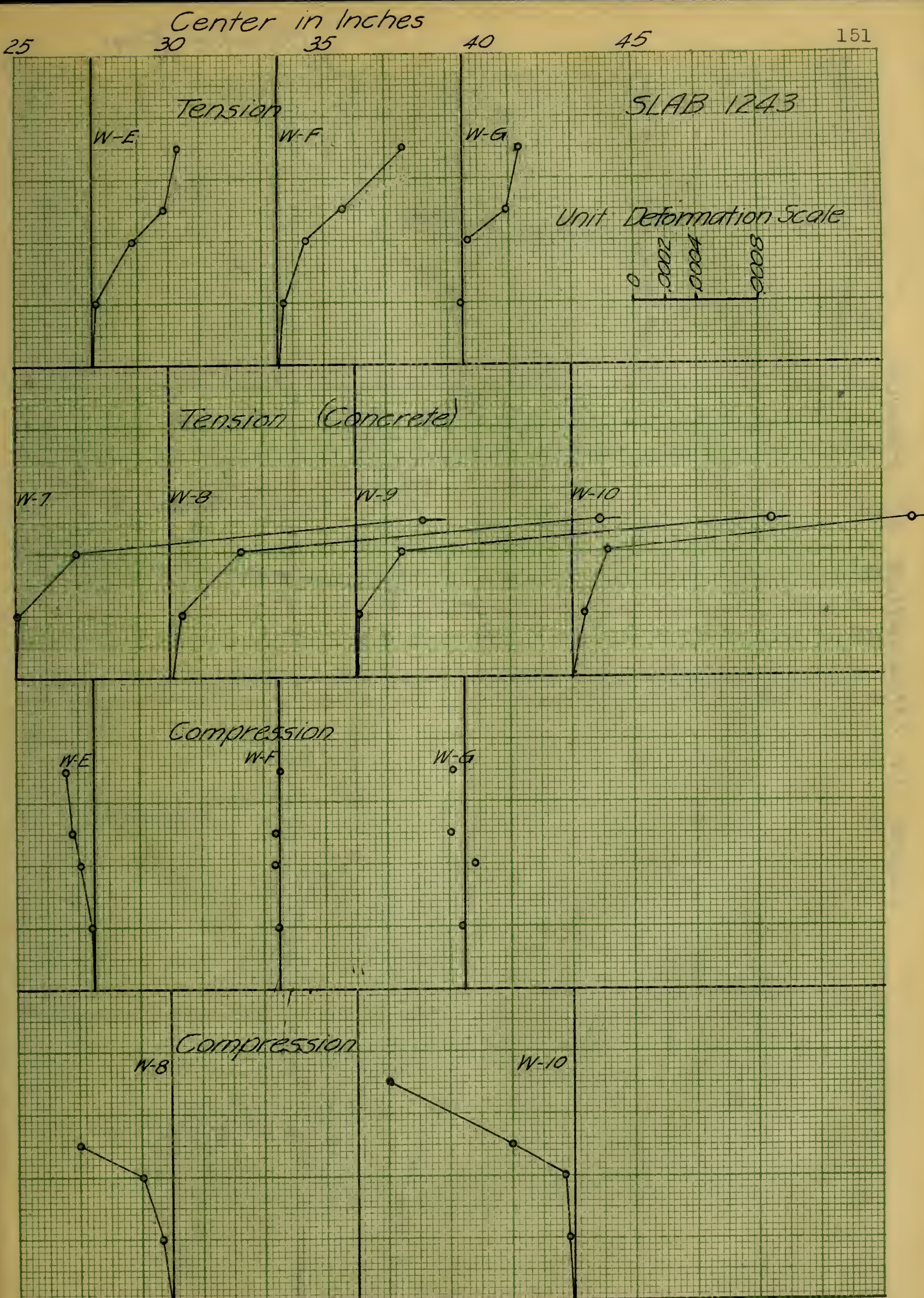

Center in Inches
25
30
35
40
45
SLAB 1243
Tension
S-E
S-F
S-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension (Concrete)
S-7
S-8
S-9
S-10
Compression
S-E
S-F
S-G
Compression
S-8
S-9
S-10

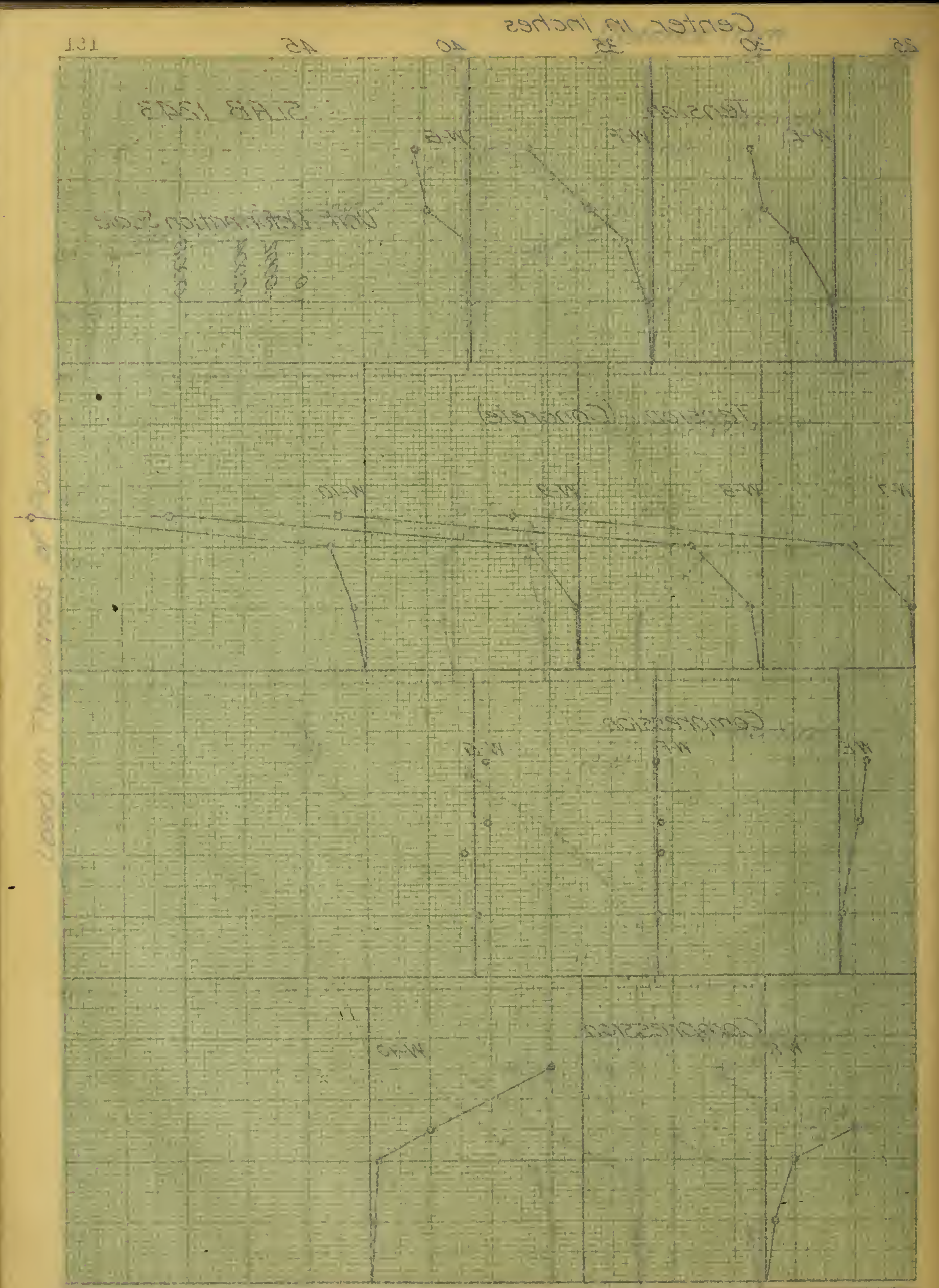



Distance from
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

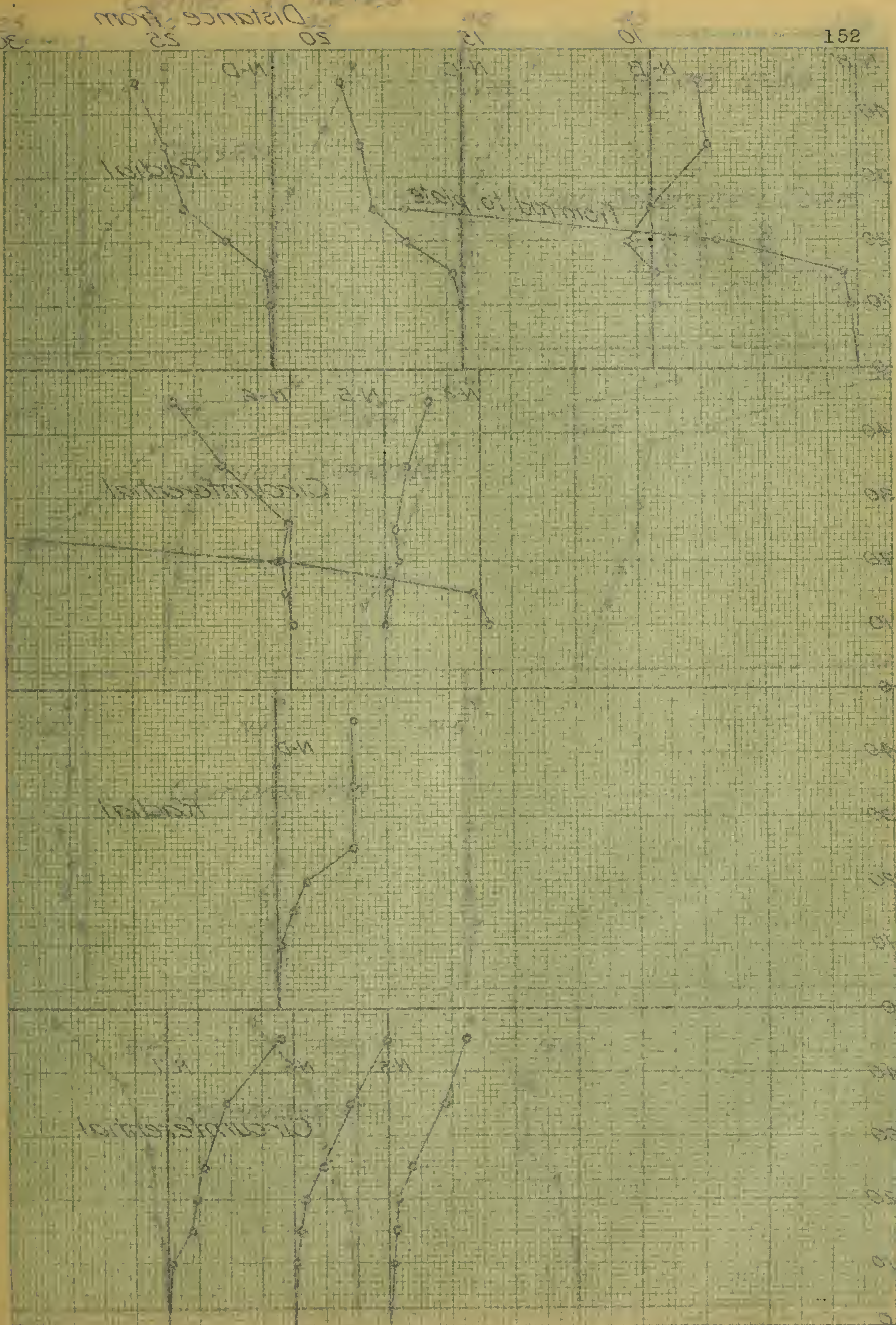


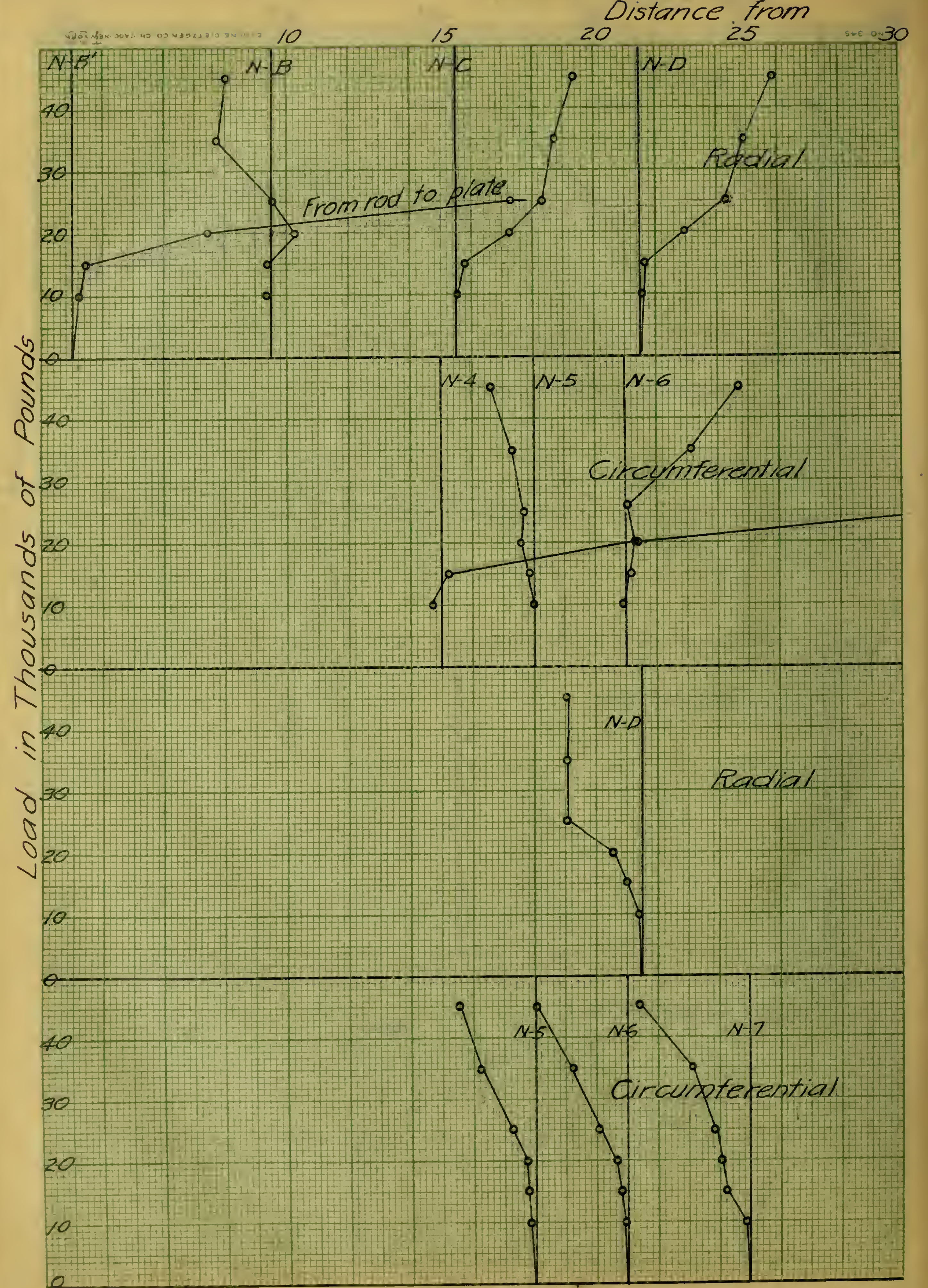
Distance from
15
20
25
30
Load in Thousands of Pounds
Radial
W-B'
W-C
W-D
From rod to plate
Circumferential
W-4
W-5
W-6
Radial
W-D
Circumferential
W-5
W-6
W-7
W-8


Center in Inches
25
30
35
40
45
SLAB 1243
Tension
W-E
W-F
W-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension (Concrete)
W-7
W-8
W-9
W-10
Compression
W-E
W-F
W-G
Compression
W-8
W-10

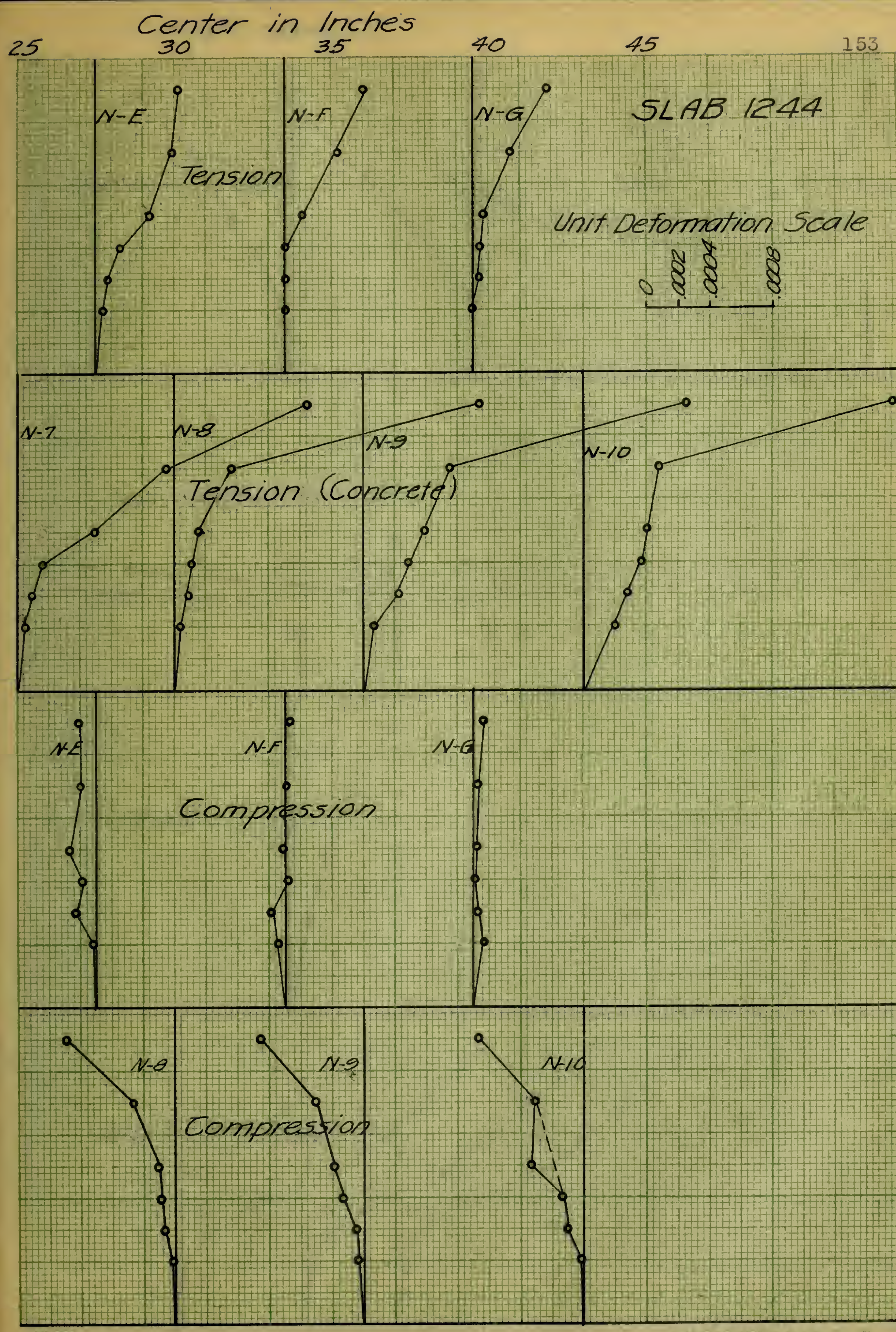


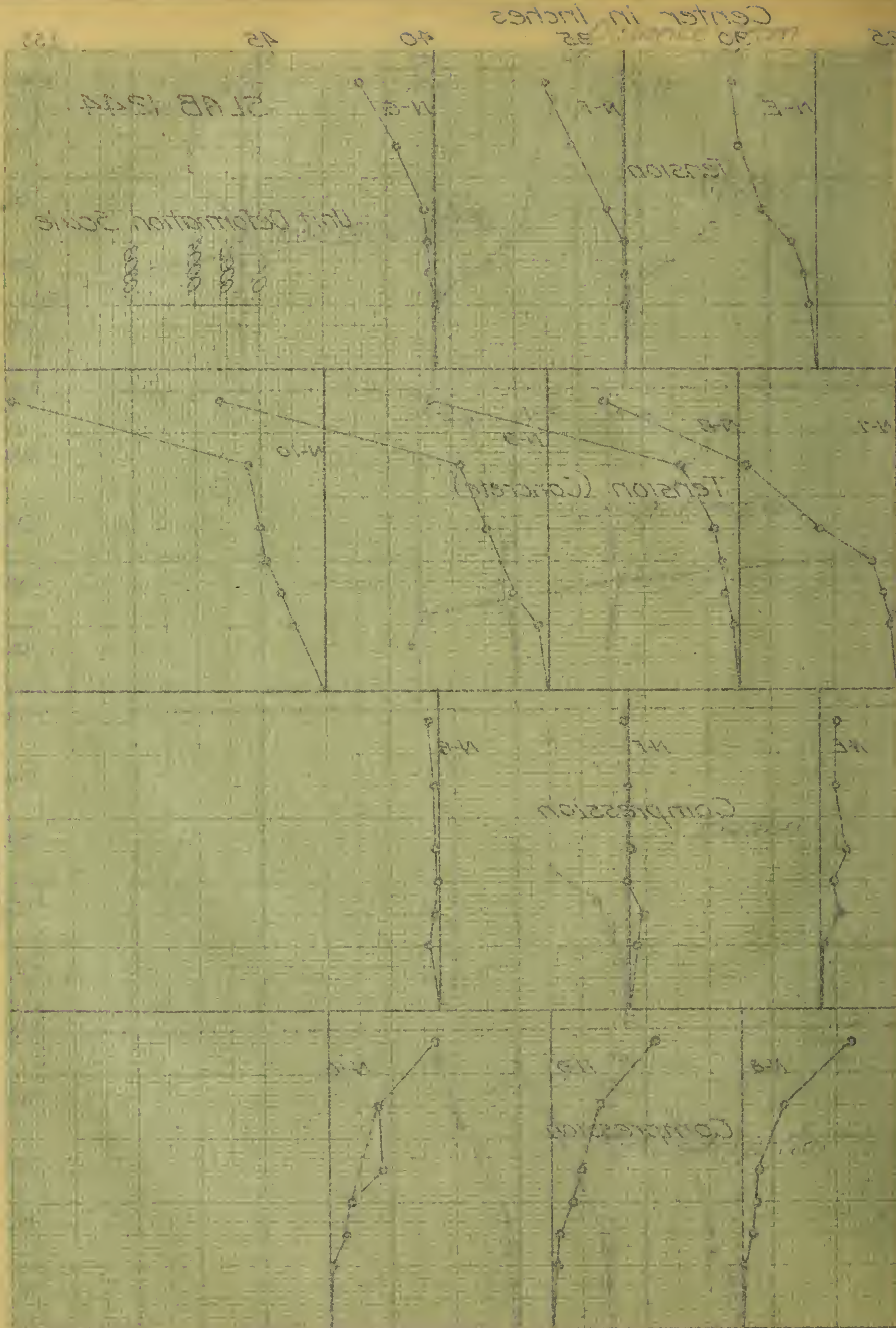
Center in inches
25
30
35
40
45
SLAB 1305
Tension
Compression

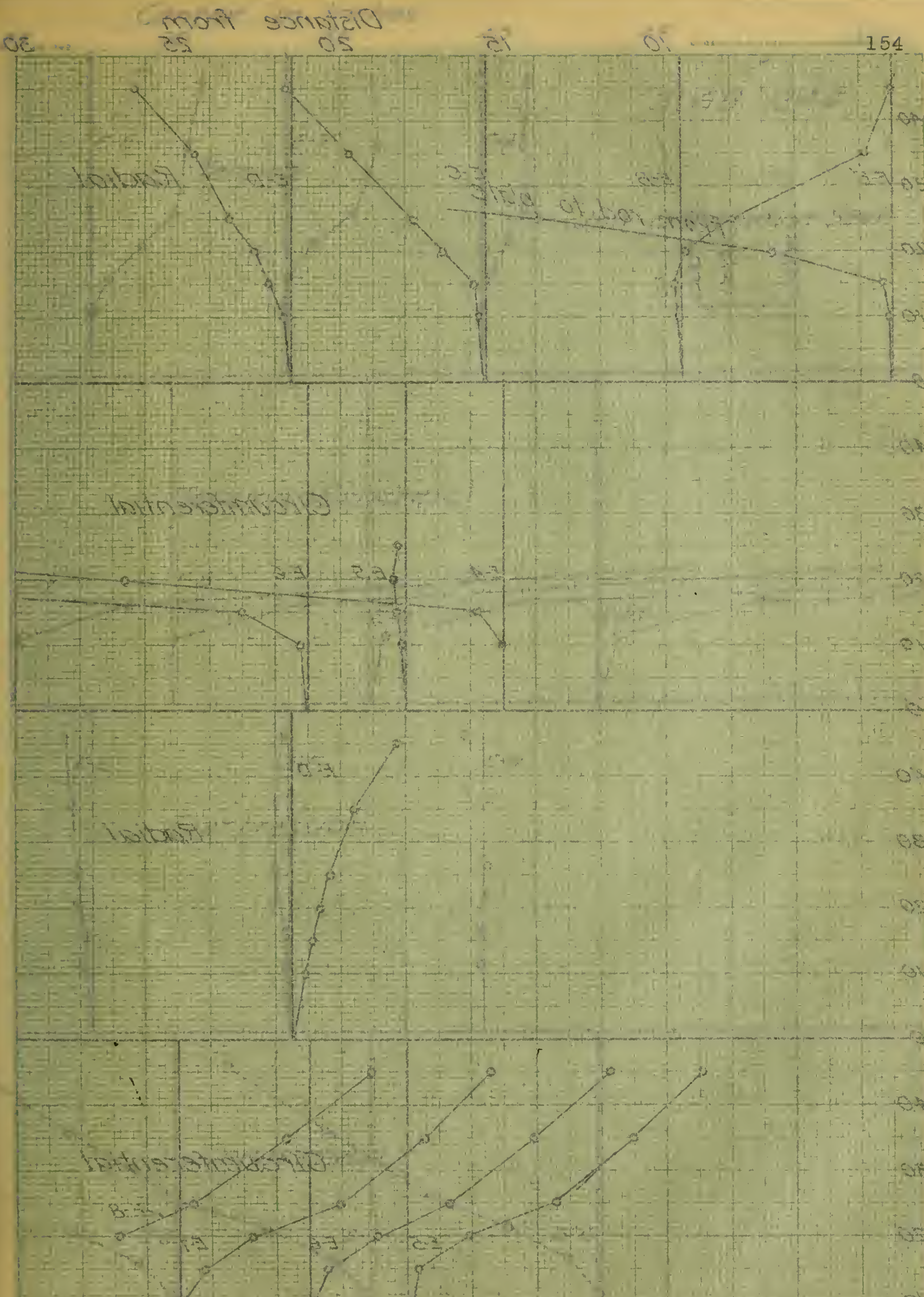


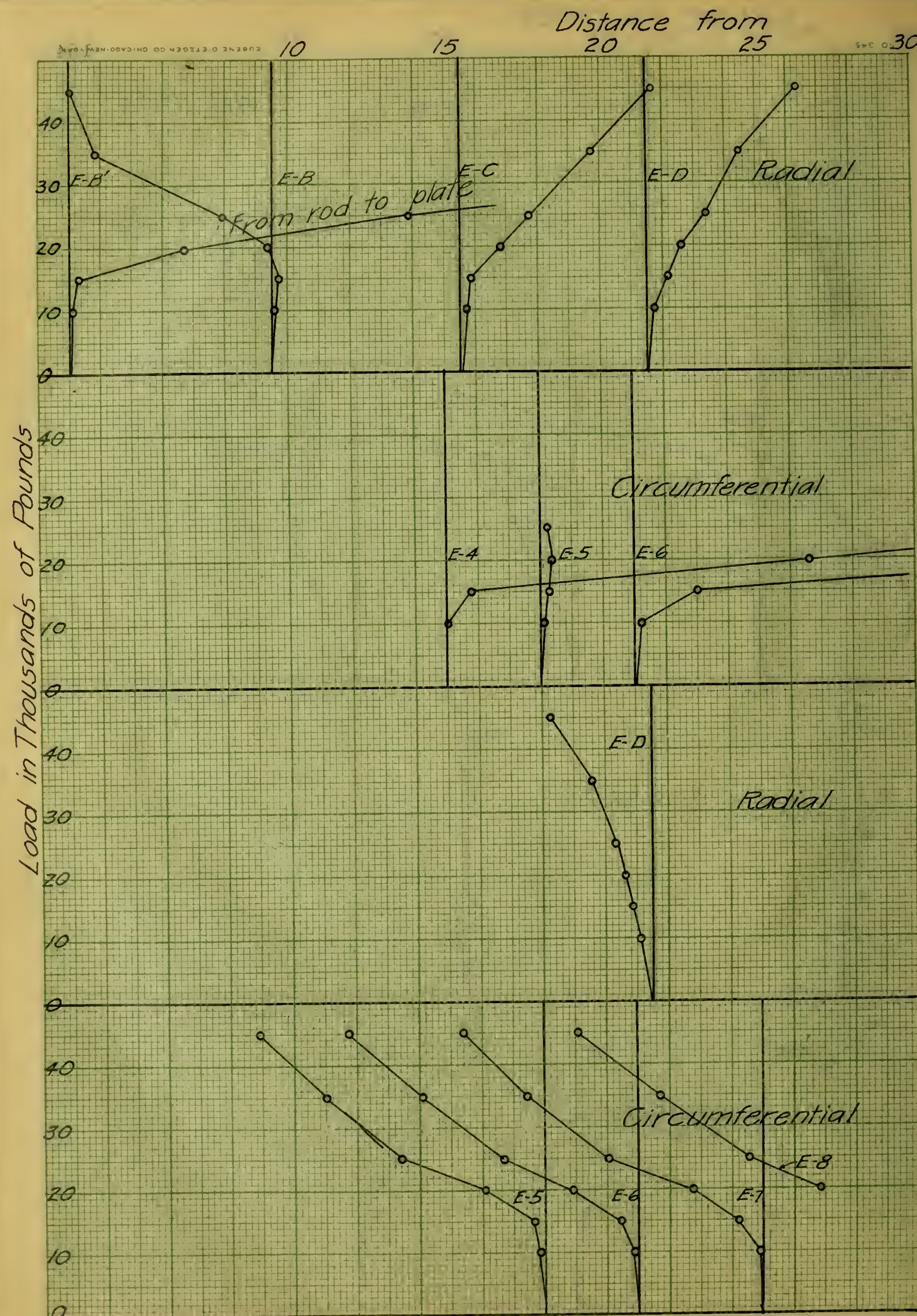


Distance from
10
15
20
25
30
N-B'
N-B
N-C
N-D
From rod to plate
Radial
N-4
N-5
N-6
Circumferential
N-D
Radial
N-5
N-6
N-7
Circumferential
Load in Thousands of Pounds
0
10
20
30
40

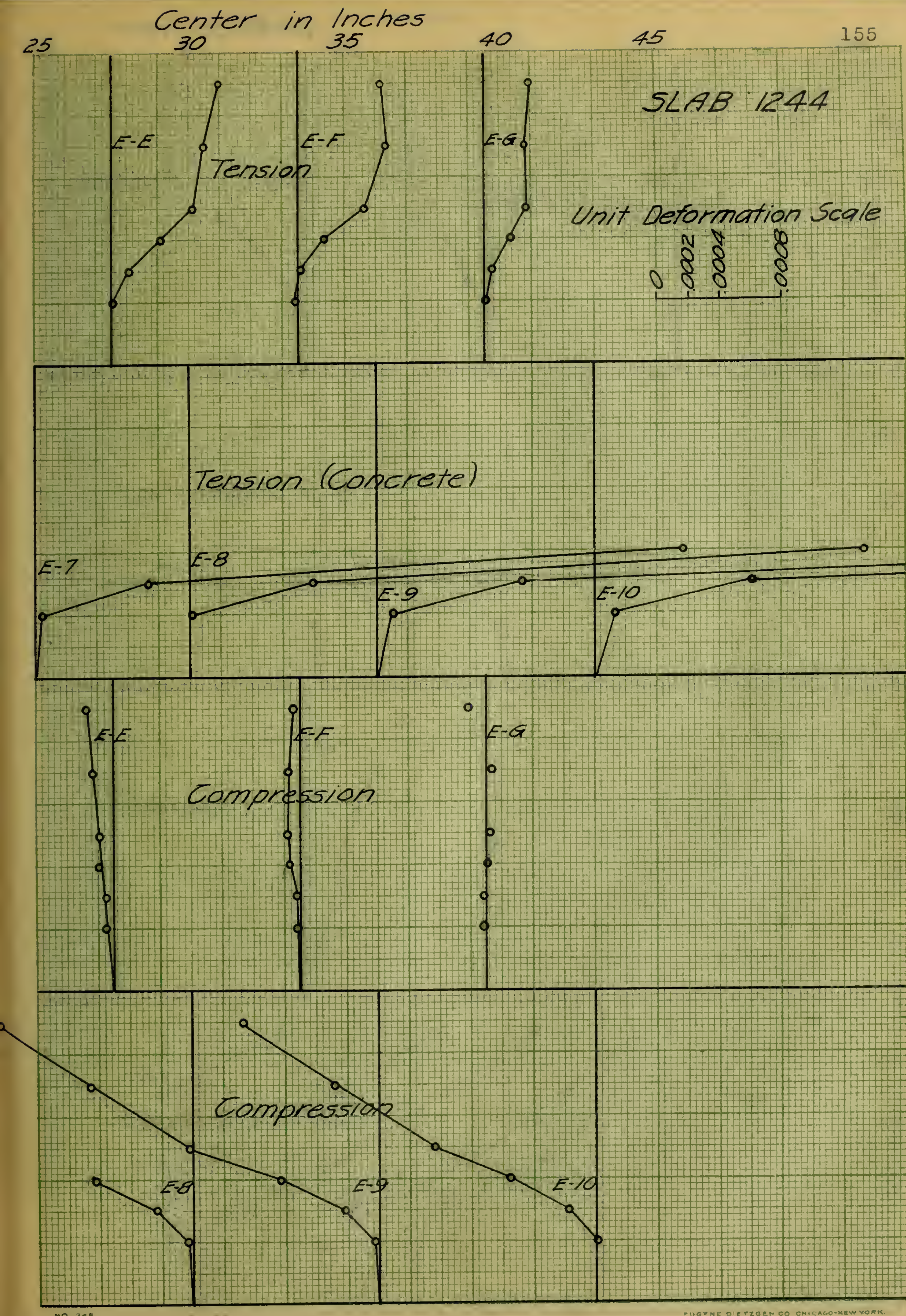

Center in Inches
25
30
35
40
45
SLAB 1244
N-E
N-F
N-G
Tension
Unit Deformation Scale
0
.0002
.0004
.0008
N-7
N-8
N-9
N-10
Tension (Concrete)
N-E
N-F
N-G
Compression
N-8
N-9
N-10
Compression


Center in Inches
25
30
35
40
45
SLAB 12-14
Unit Deformation Scale
Tension
Tension (Concrete)
Compression
Compression

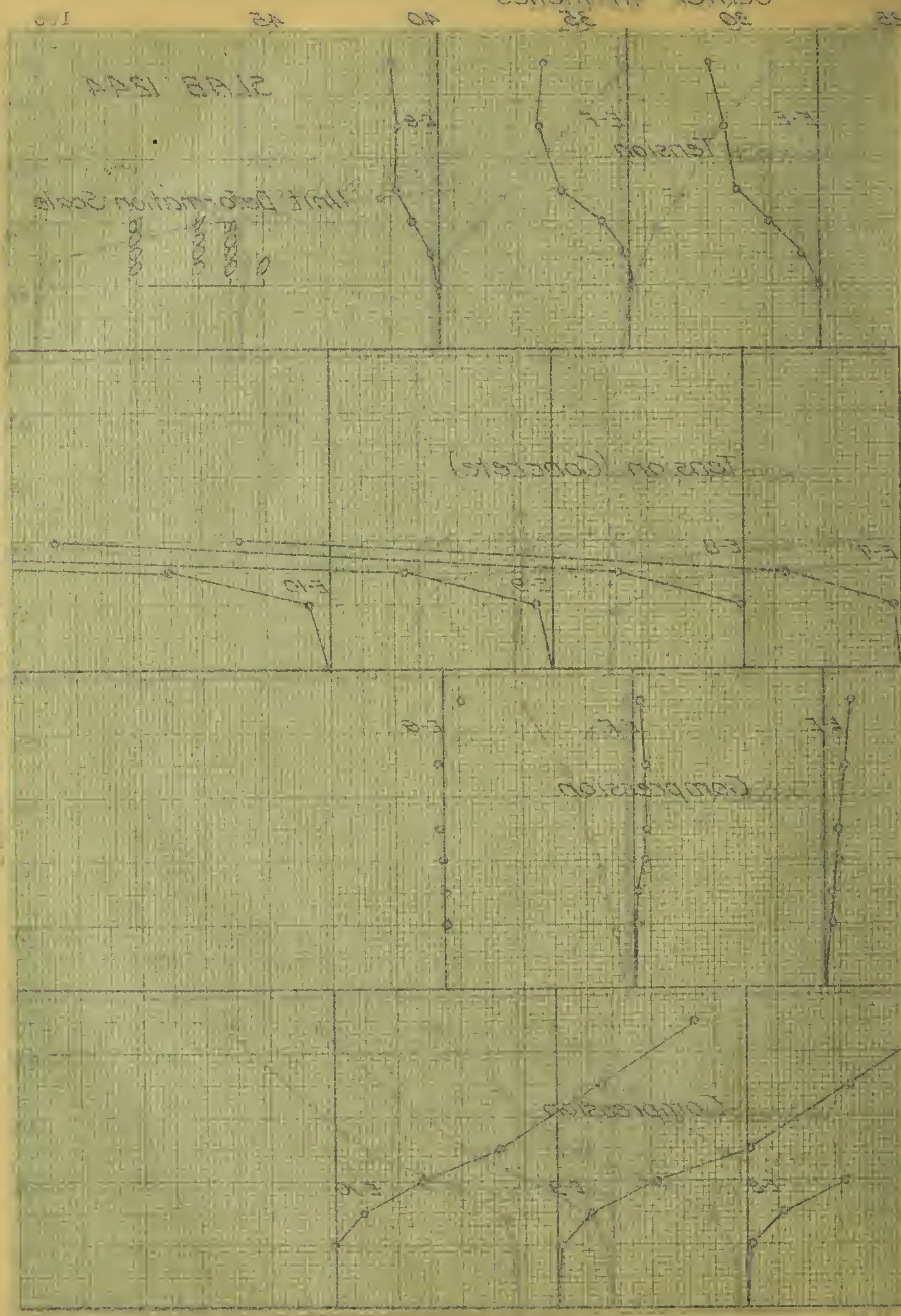


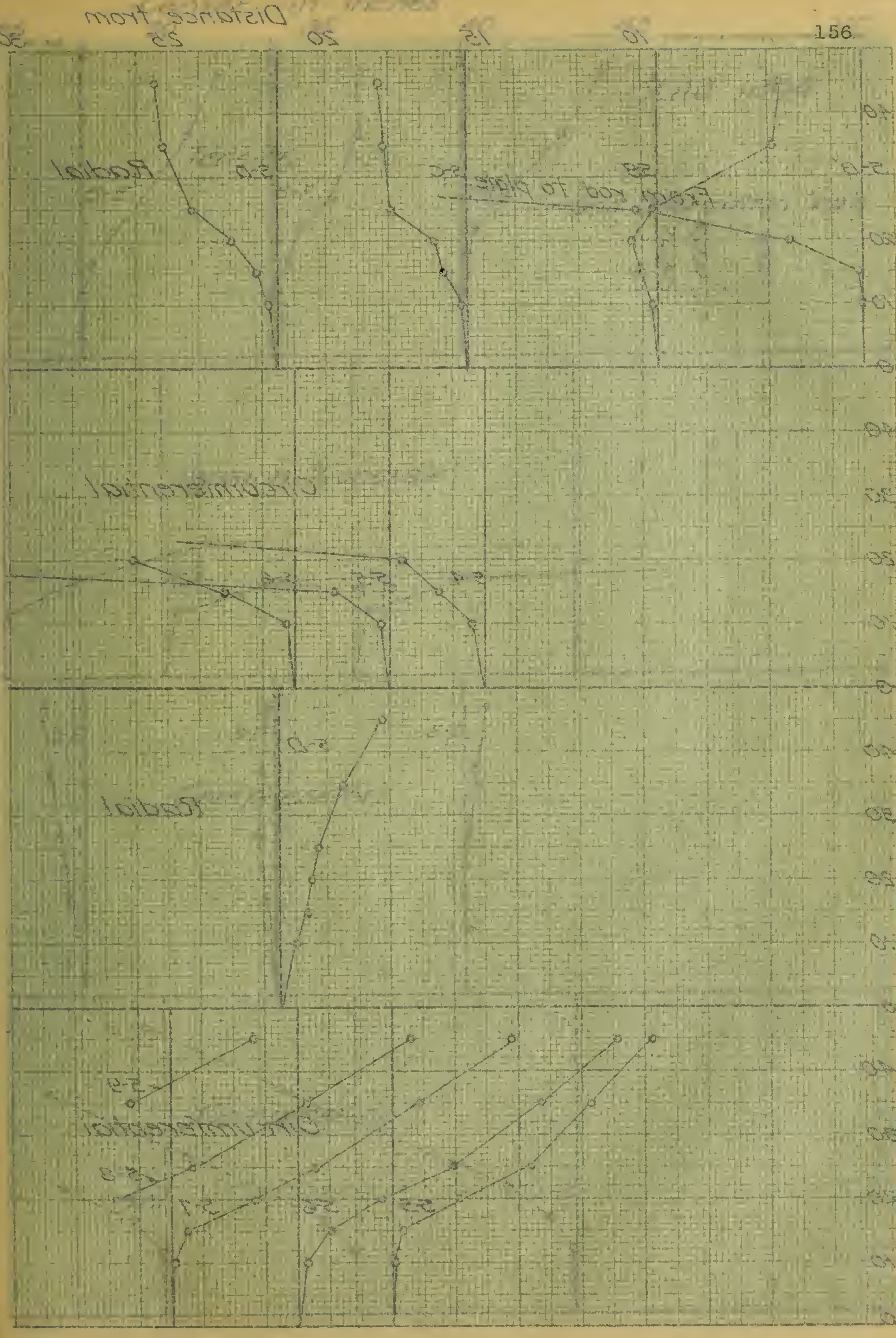


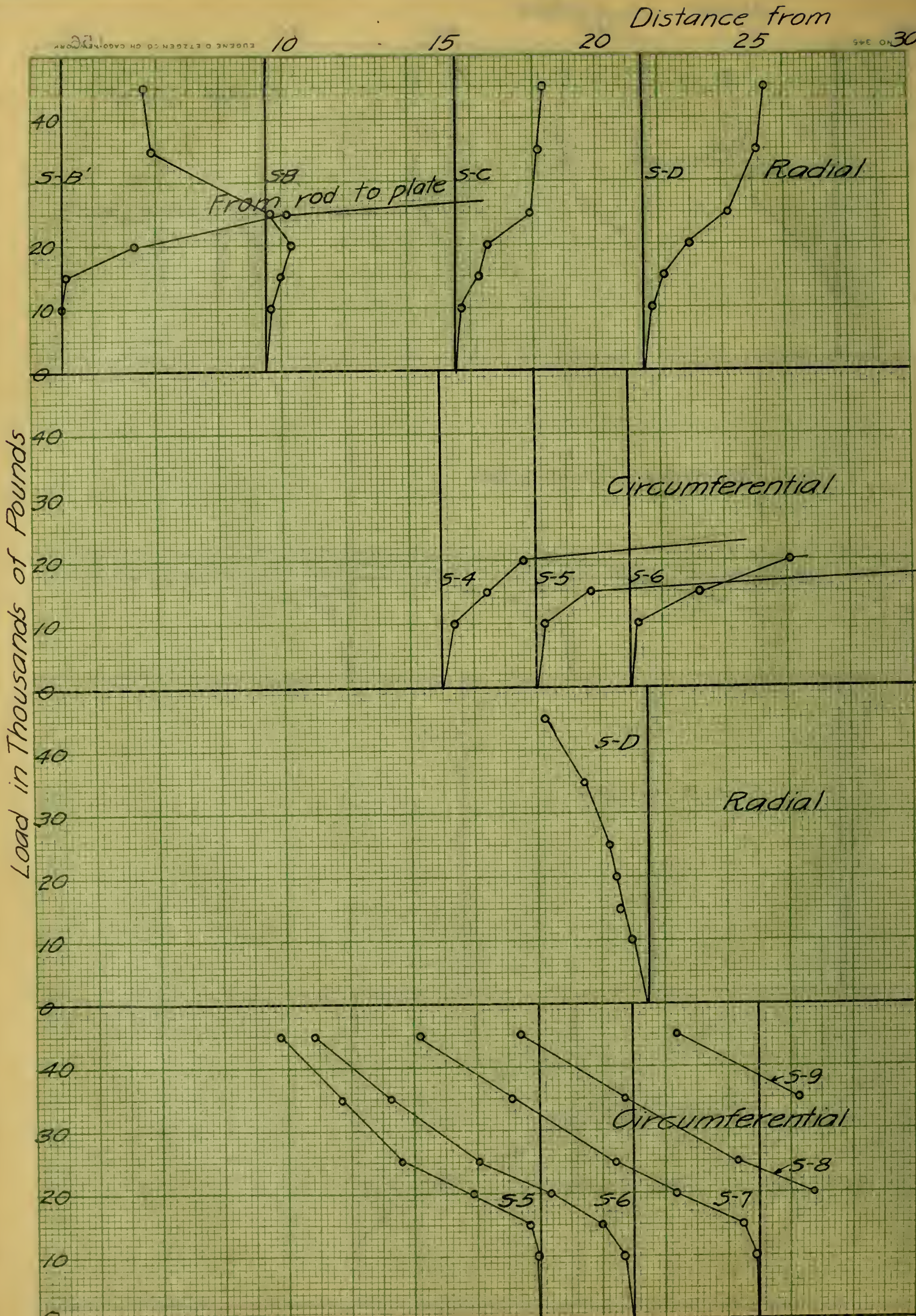
Distance from rod to plate
10
15
20
25
30
Load in Thousands of Pounds
0
10
20
30
40
E-B'
E-B
E-C
E-D
Radial
E-4
E-5
E-6
Circumferential
E-D
Radial
E-5
E-6
E-7
E-8
Circumferential

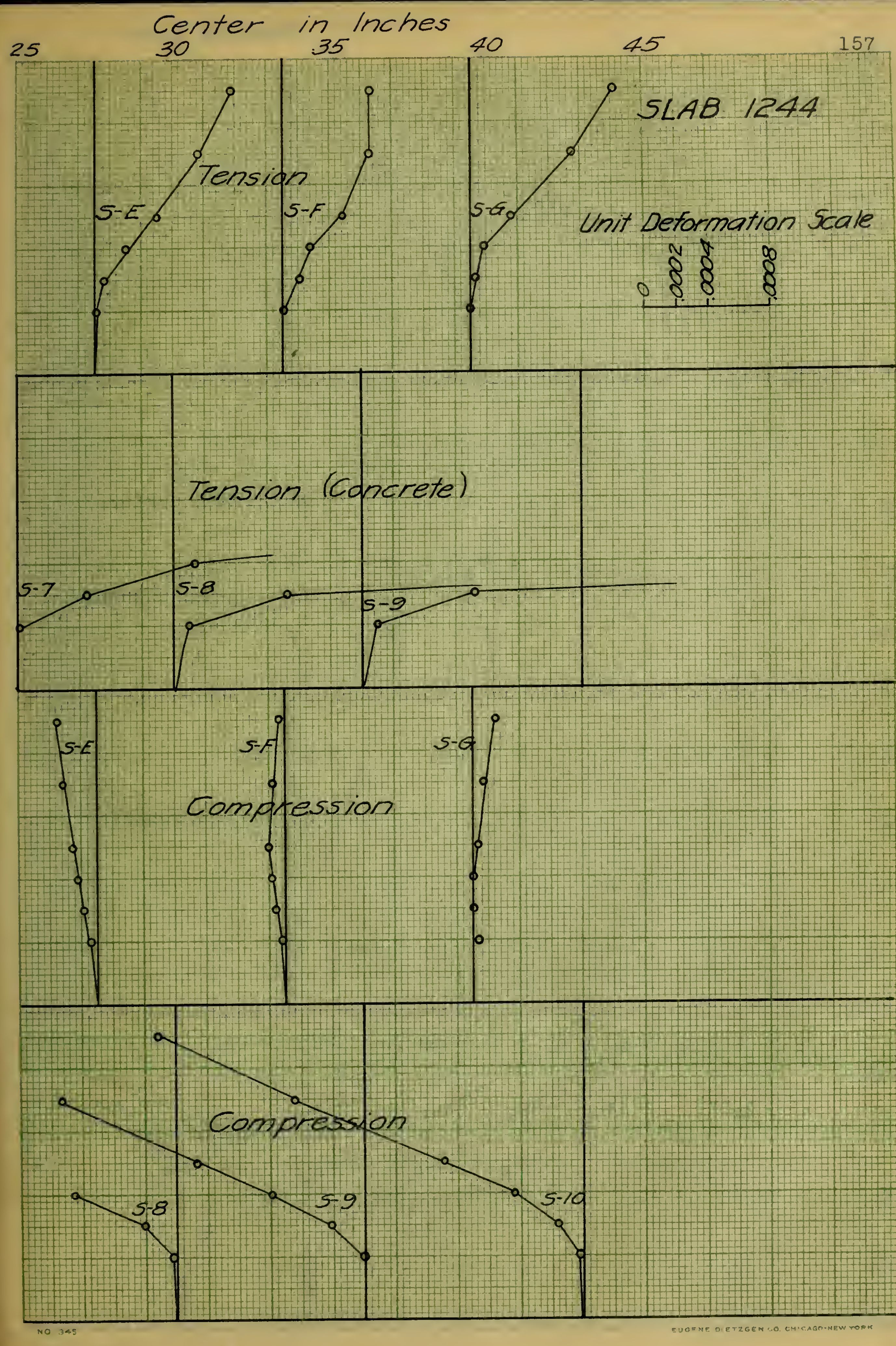


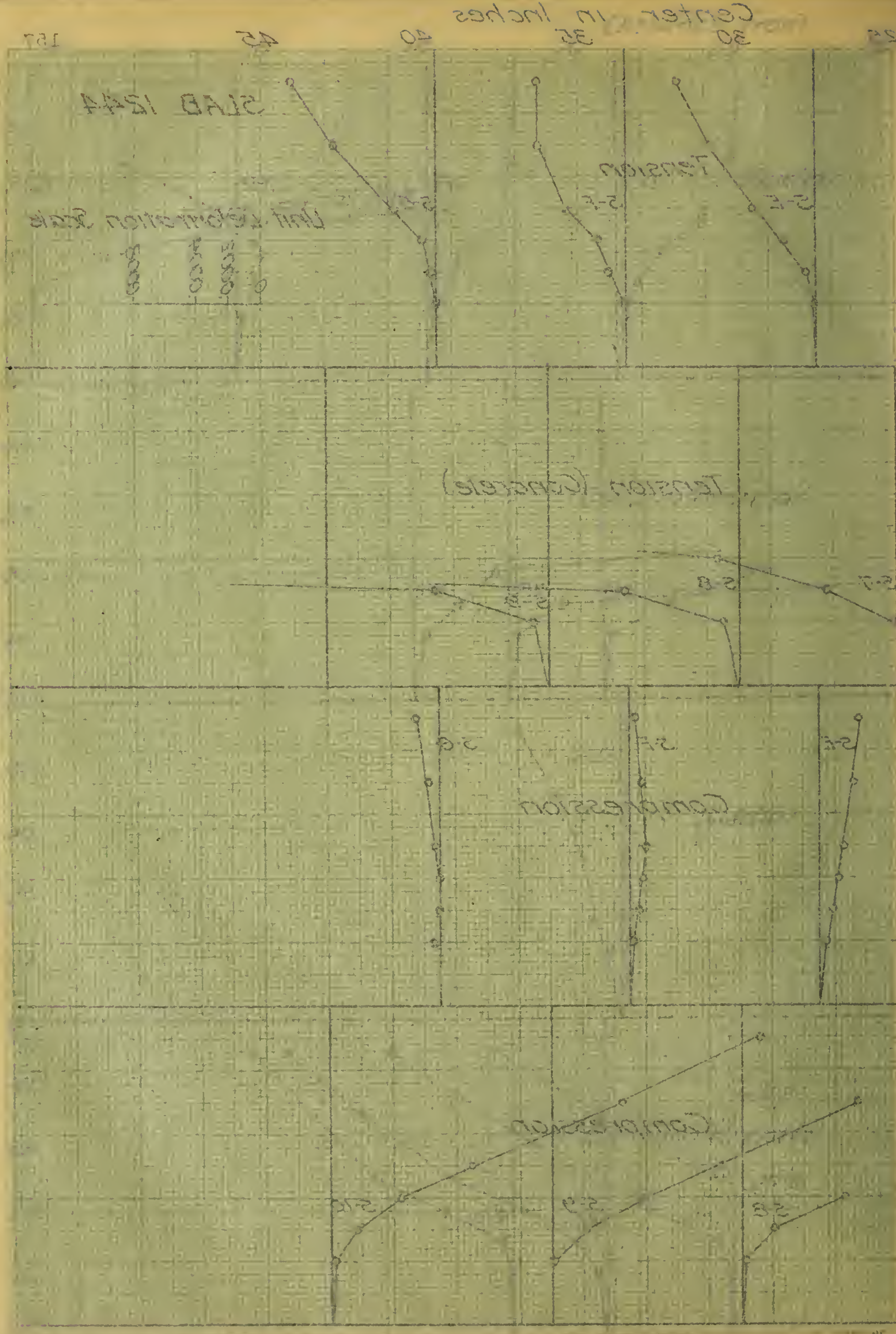
Center in Inches
25
30
35
40
45
SLAB 1244
E-E
E-F
E-G
Tension
Unit Deformation Scale
0
.0002
.0004
.0008
Tension (Concrete)
E-7
E-8
E-9
E-10
E-E
E-F
E-G
Compression
Compression
E-8
E-9
E-10
NO 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK.


SLAB 1244
Center in Inches
Tension
Compression
Tension on Concrete
Unit Deformation Scale
Load in Thousands of Pounds

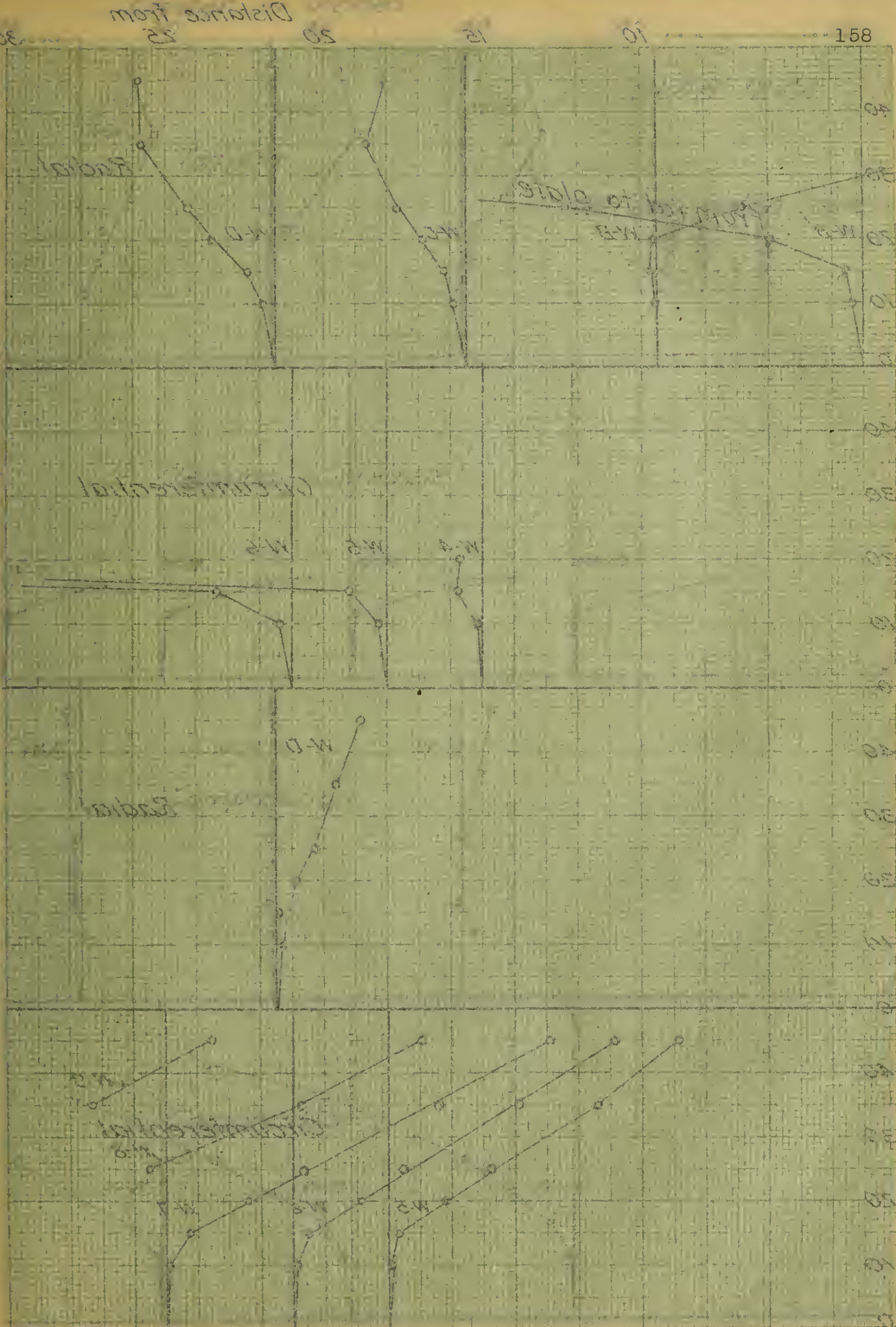


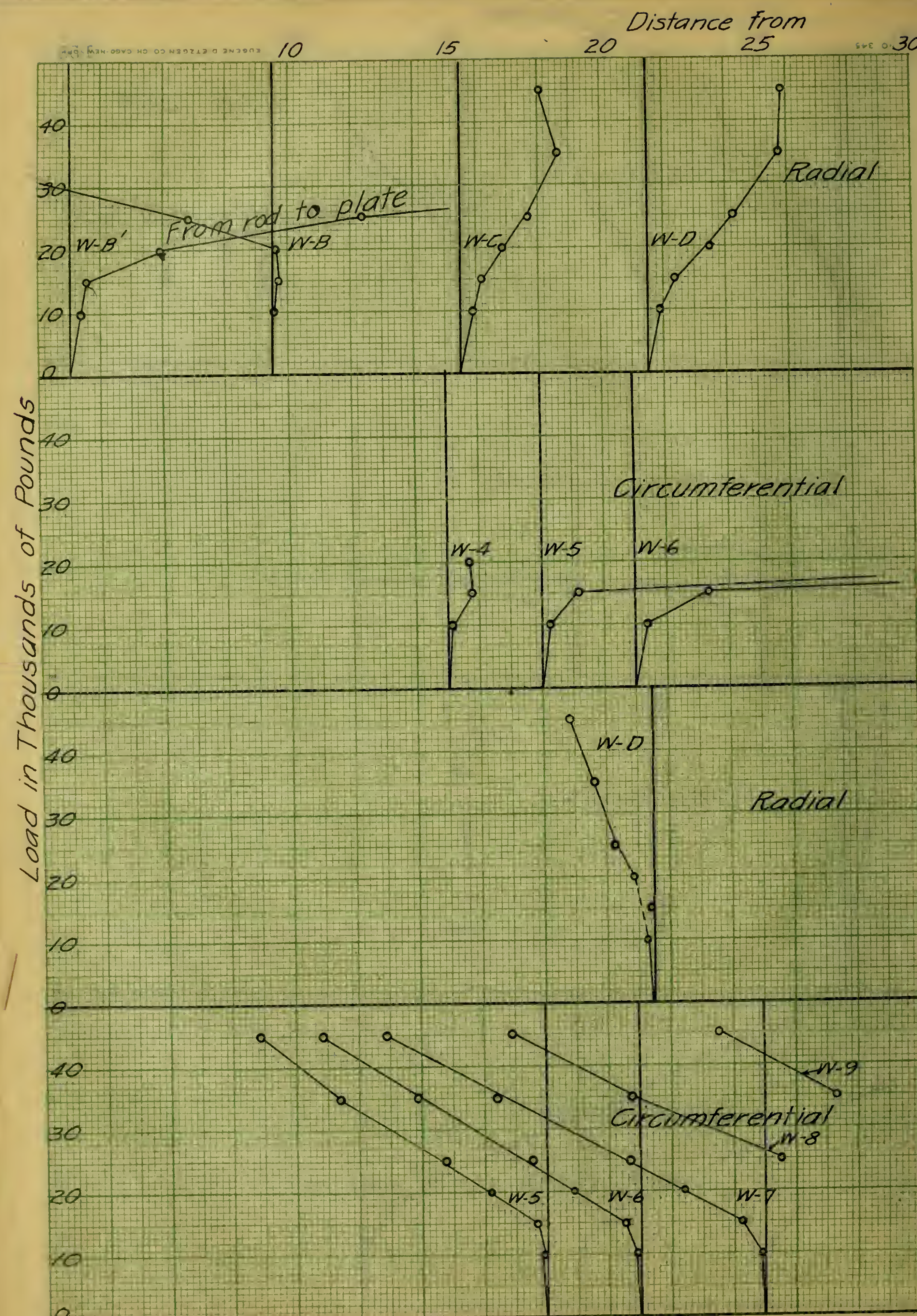

Distance from
10
15
20
25
30
Load in Thousands of Pounds
40
20
10
0
S-B'
SB
S-C
S-D
Radial
From rod to plate
40
30
20
10
0
Circumferential
S-4
S-5
S-6
40
30
20
10
0
S-D
Radial
40
30
20
10
0
Circumferential
S-5
S-6
S-7
S-8
S-9


Center in Inches
25
30
35
40
45
SLAB 1244
Tension
S-E
S-F
S-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension (Concrete)
S-7
S-8
S-9
S-E
S-F
S-G
Compression
Compression
S-8
S-9
S-10
NO 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK

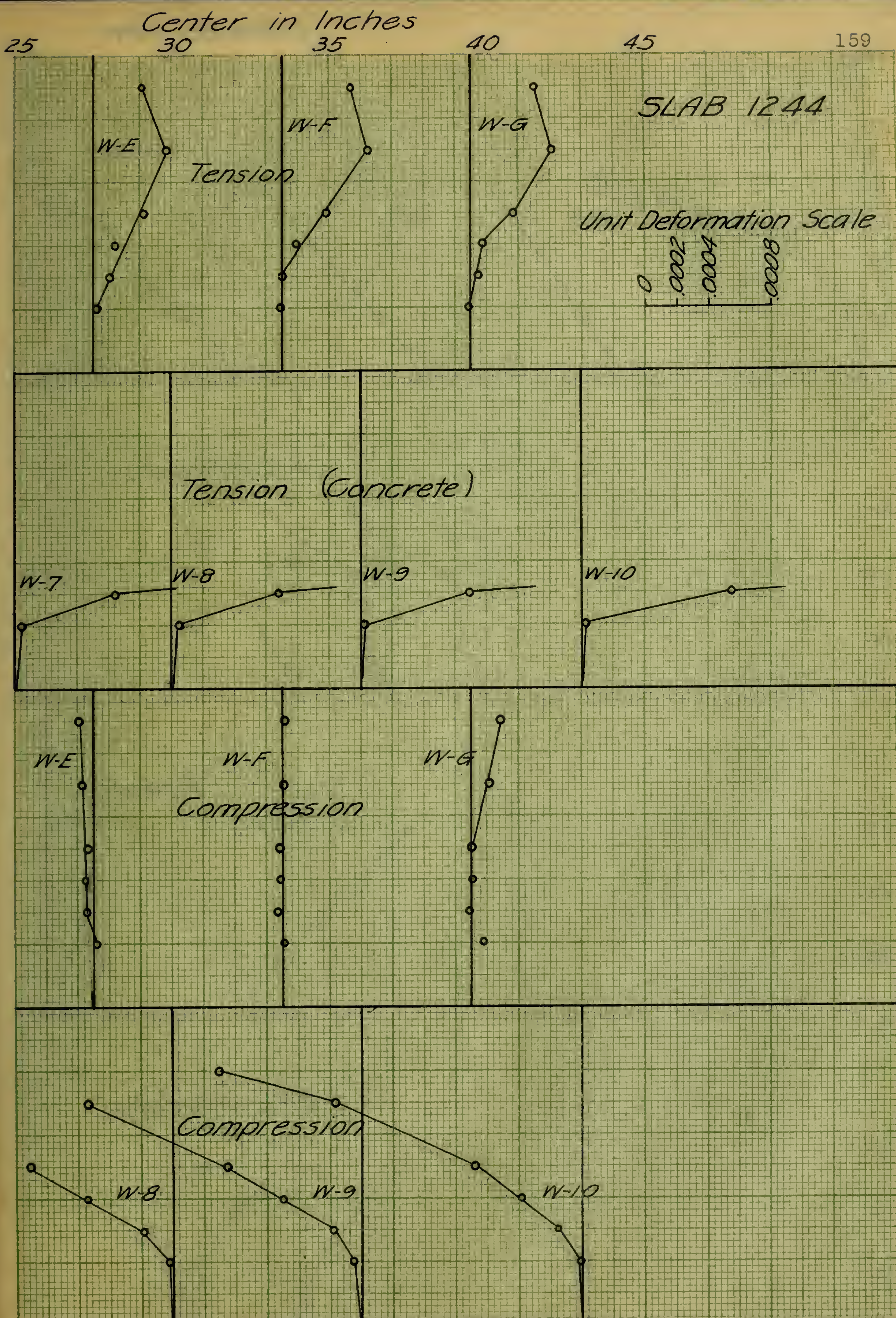


Center in Inches
25
30
35
40
45
SLAB 12-44
Tension
Unit Deformation Scale
Tension (Concrete)
Compression
Compression


Distance from
Load in Thousands of Pounds
Radial
Circumferential
Normal to plate

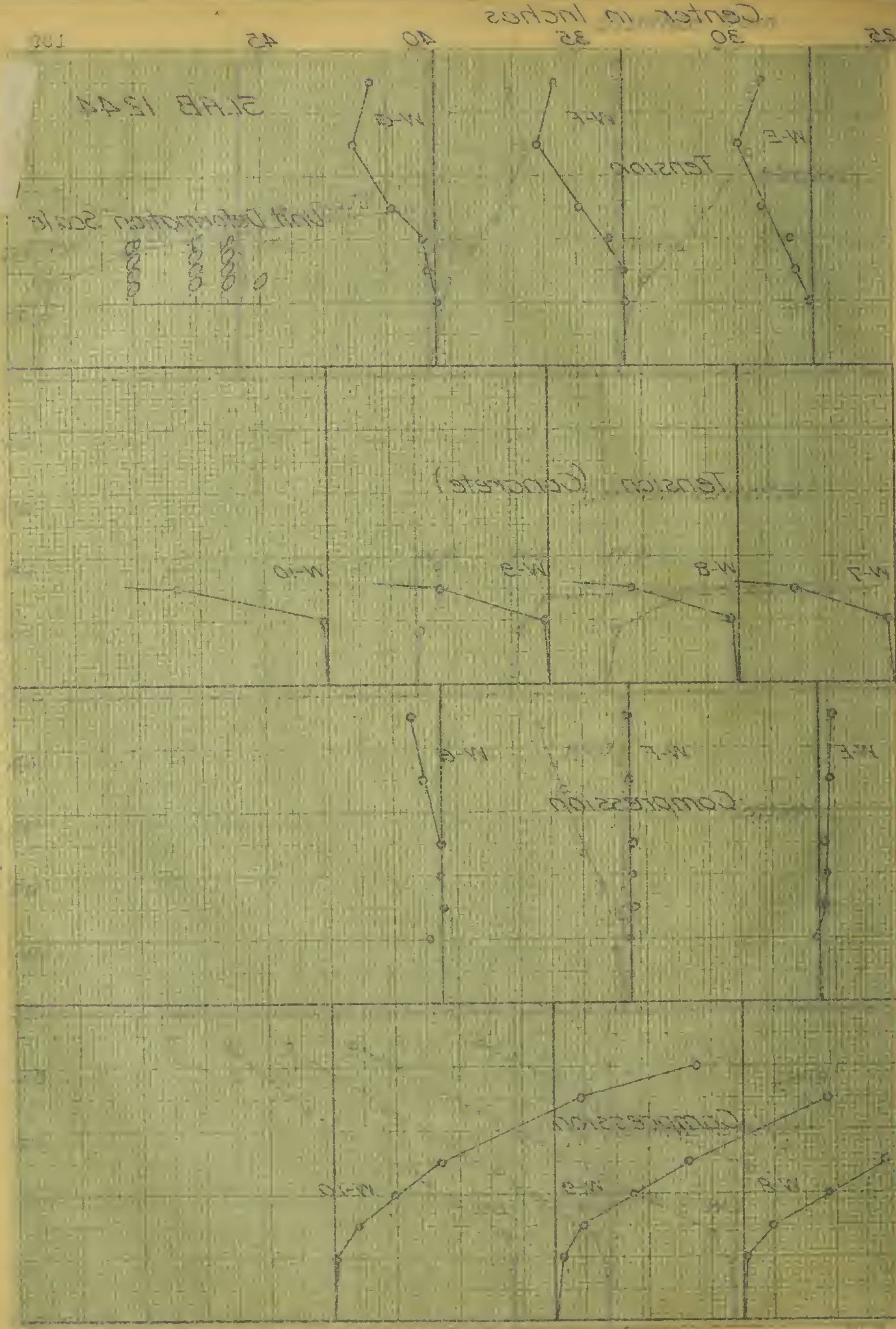


Distance from
10
15
20
25
30
Load in Thousands of Pounds
0
10
20
30
40
W-B'
From rod to plate
W-B
W-C
W-D
Radial
Circumferential
W-4
W-5
W-6
W-D
Radial
W-9
Circumferential
W-8
W-5
W-6
W-7

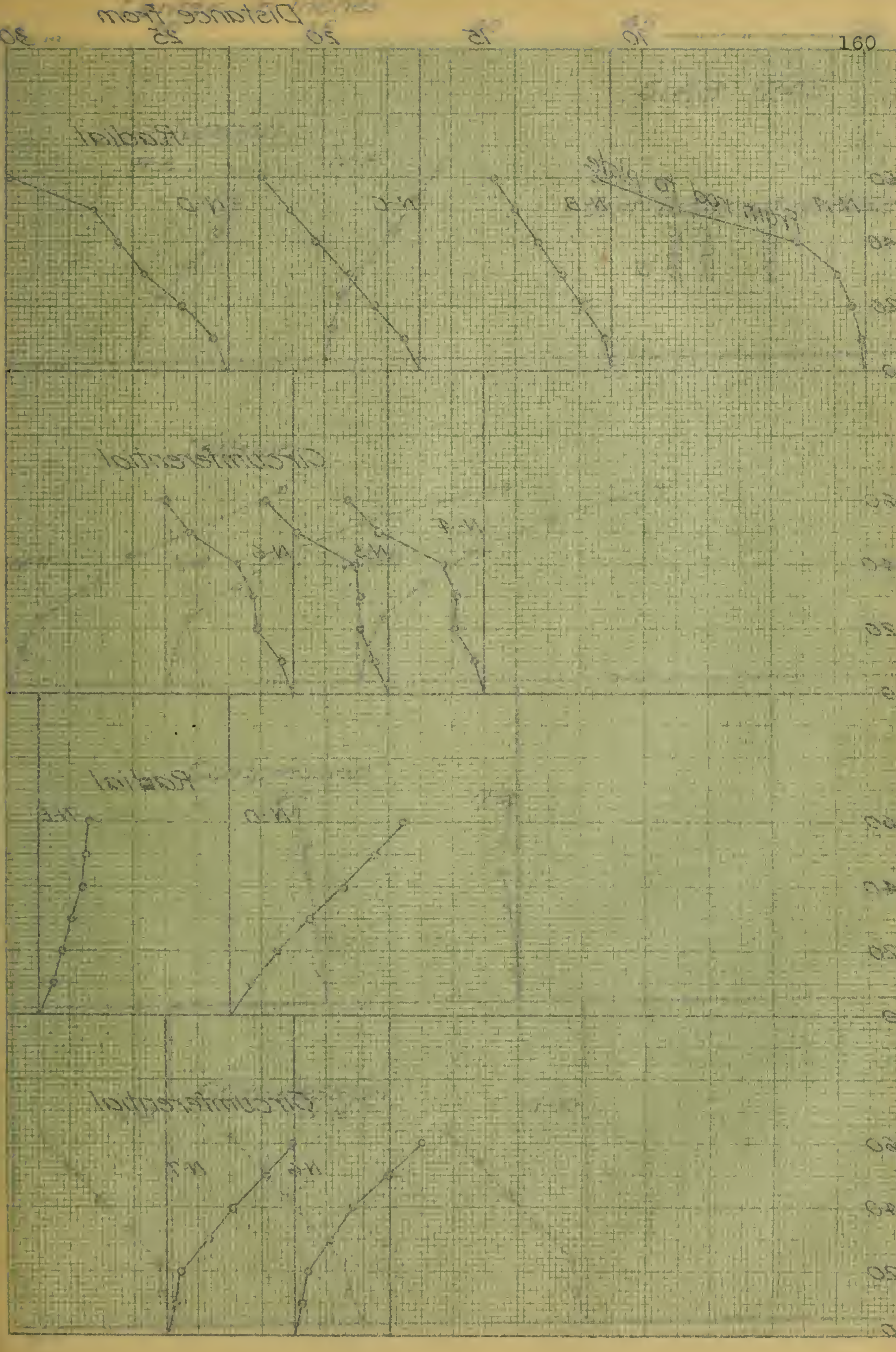


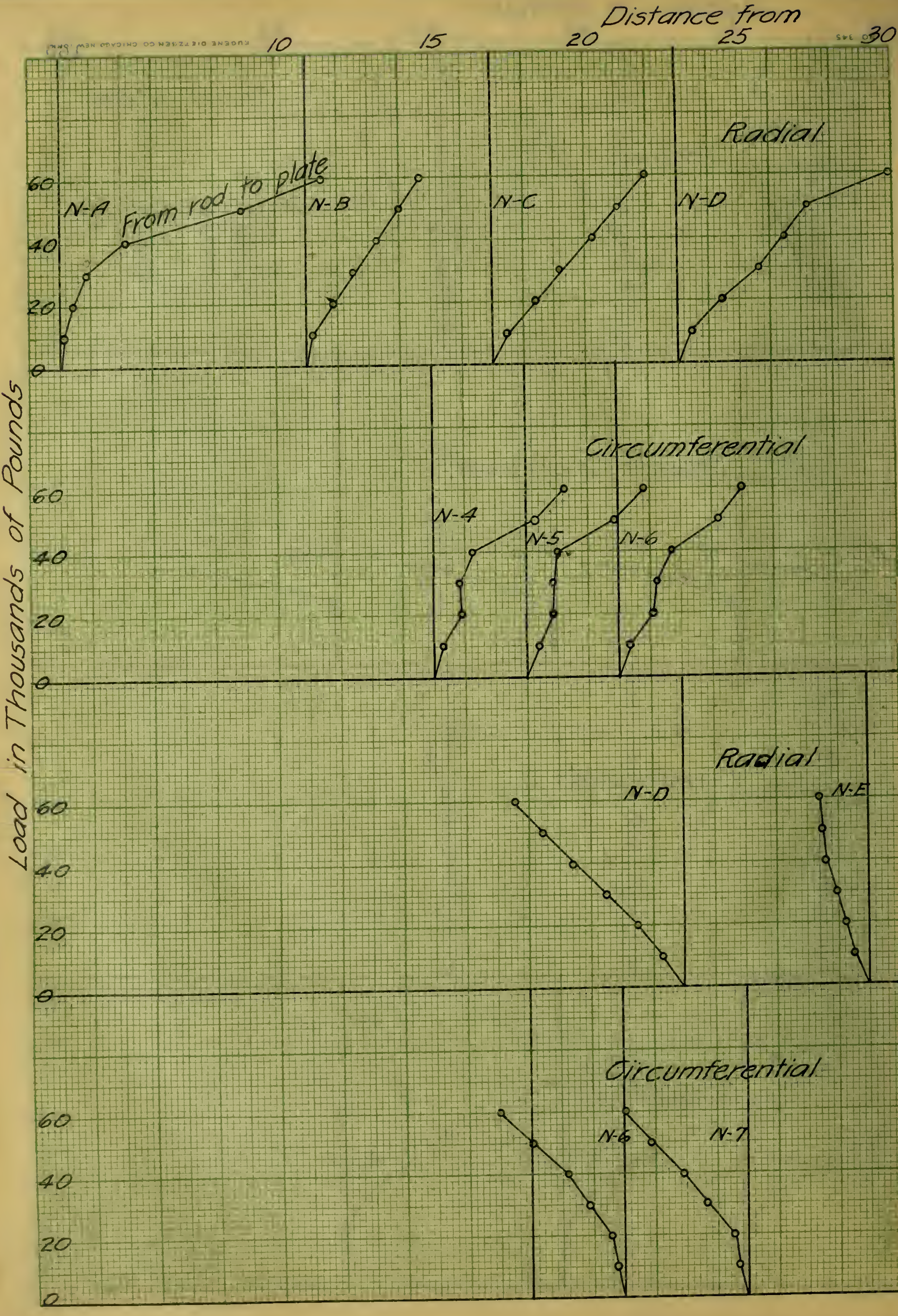
NO 345

EUGENE DIETZGEN CO. CHICAGO NEW YORK.

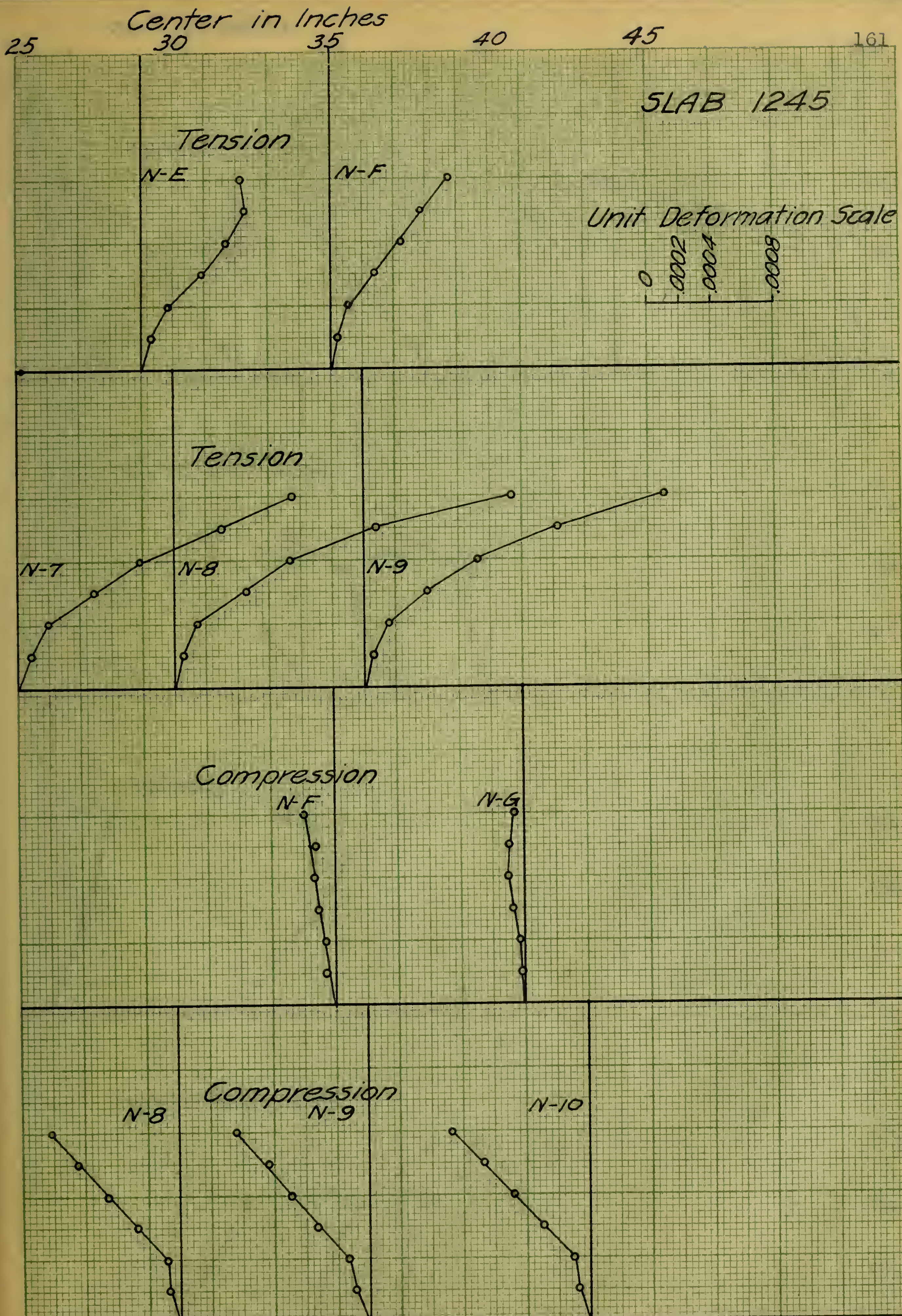


Center in Inches
25
30
35
40
45
SLAB 1243
Tension
W-E
W-F
W-G
Unit Deformation Scale
Tension (Concrete)
W-7
W-8
W-9
W-10
Compression
W-E
W-F
W-G
Compression
Load in Thousands of Pounds


Distance from
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

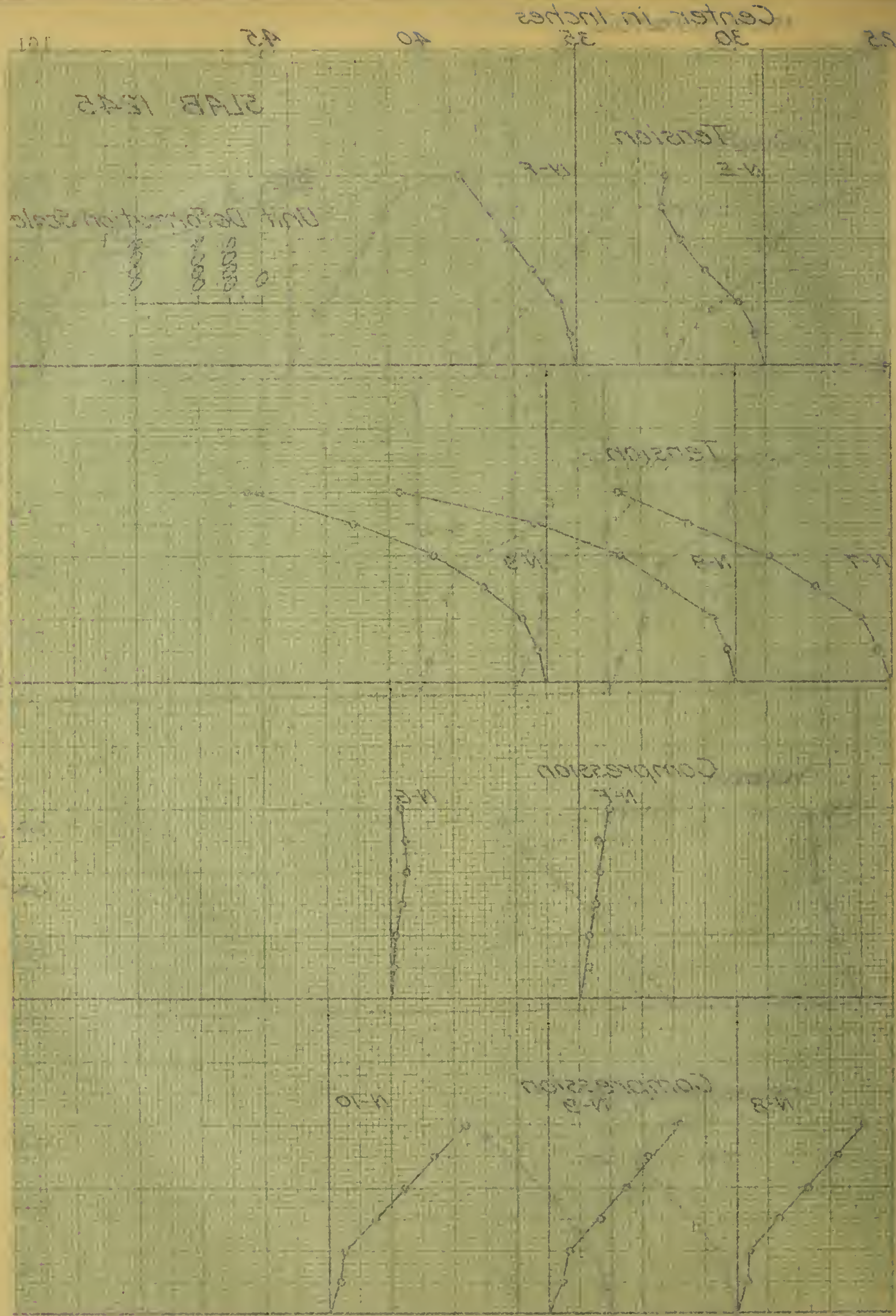


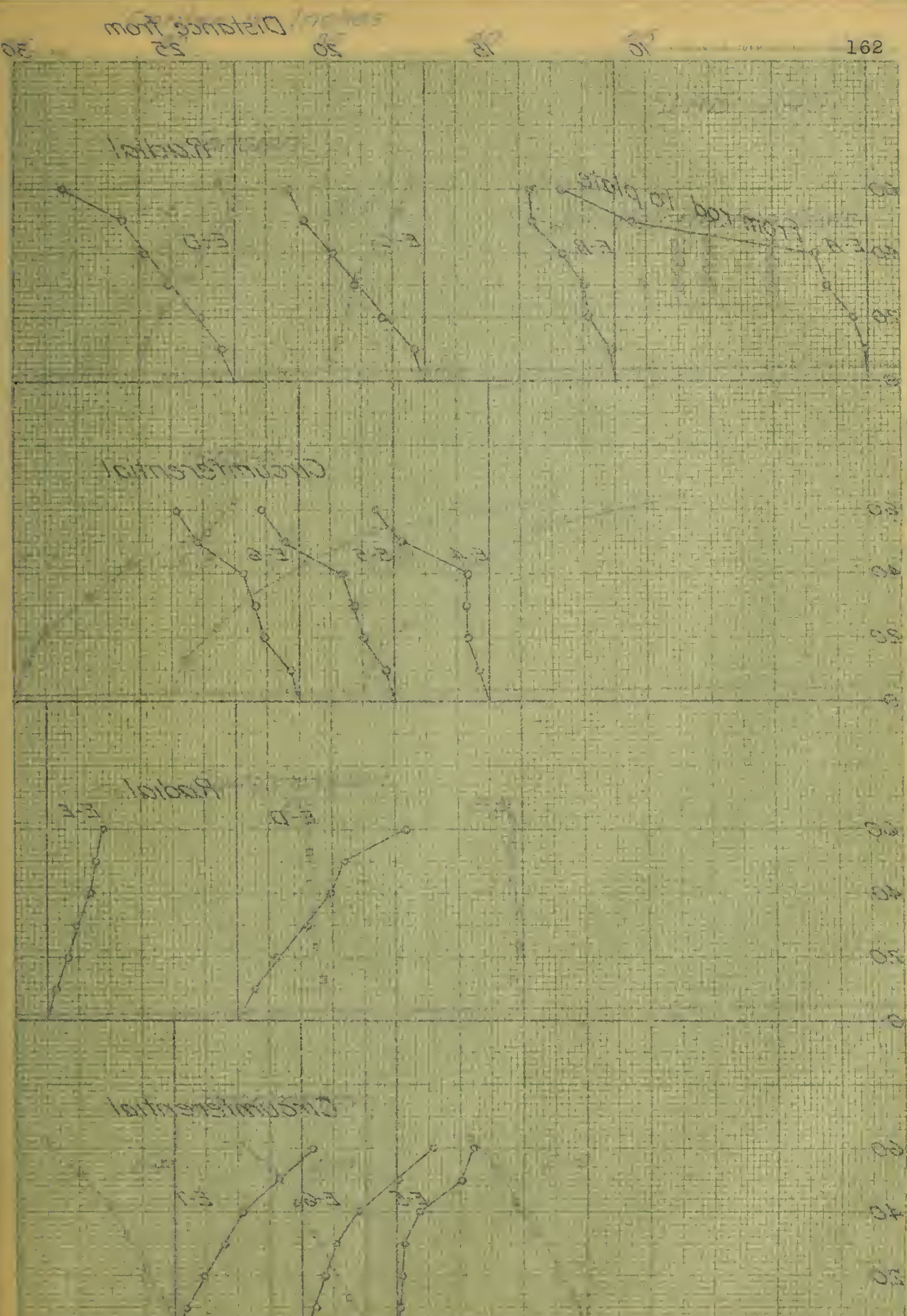
Distance from
10
15
20
25
30
Load in Thousands of Pounds
From rod to plate
N-A
N-B
N-C
N-D
Radial
Circumferential
N-4
N-5
N-6
Radial
N-D
N-E
Circumferential
N-6
N-7
60
40
20
0

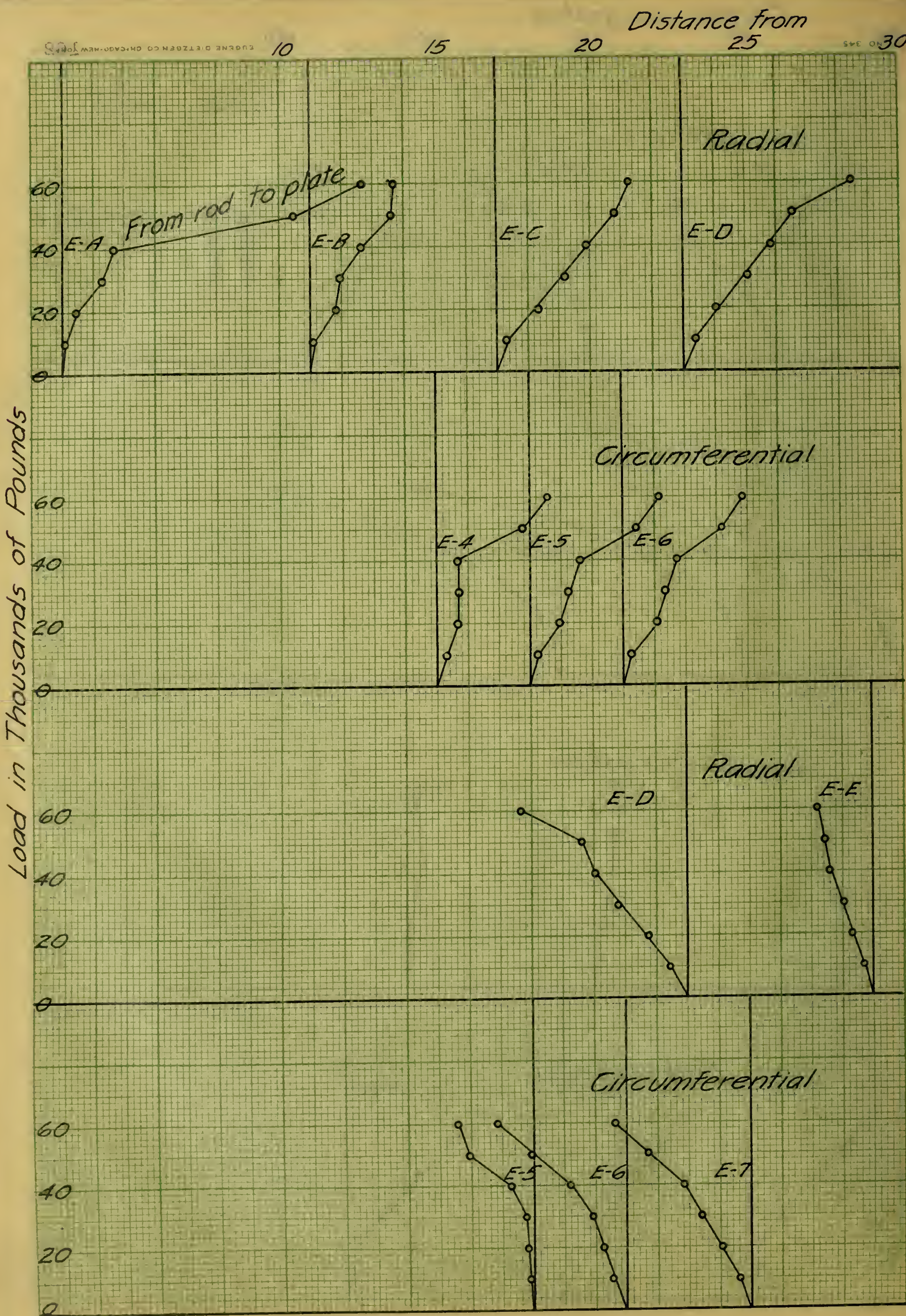


NO. 345

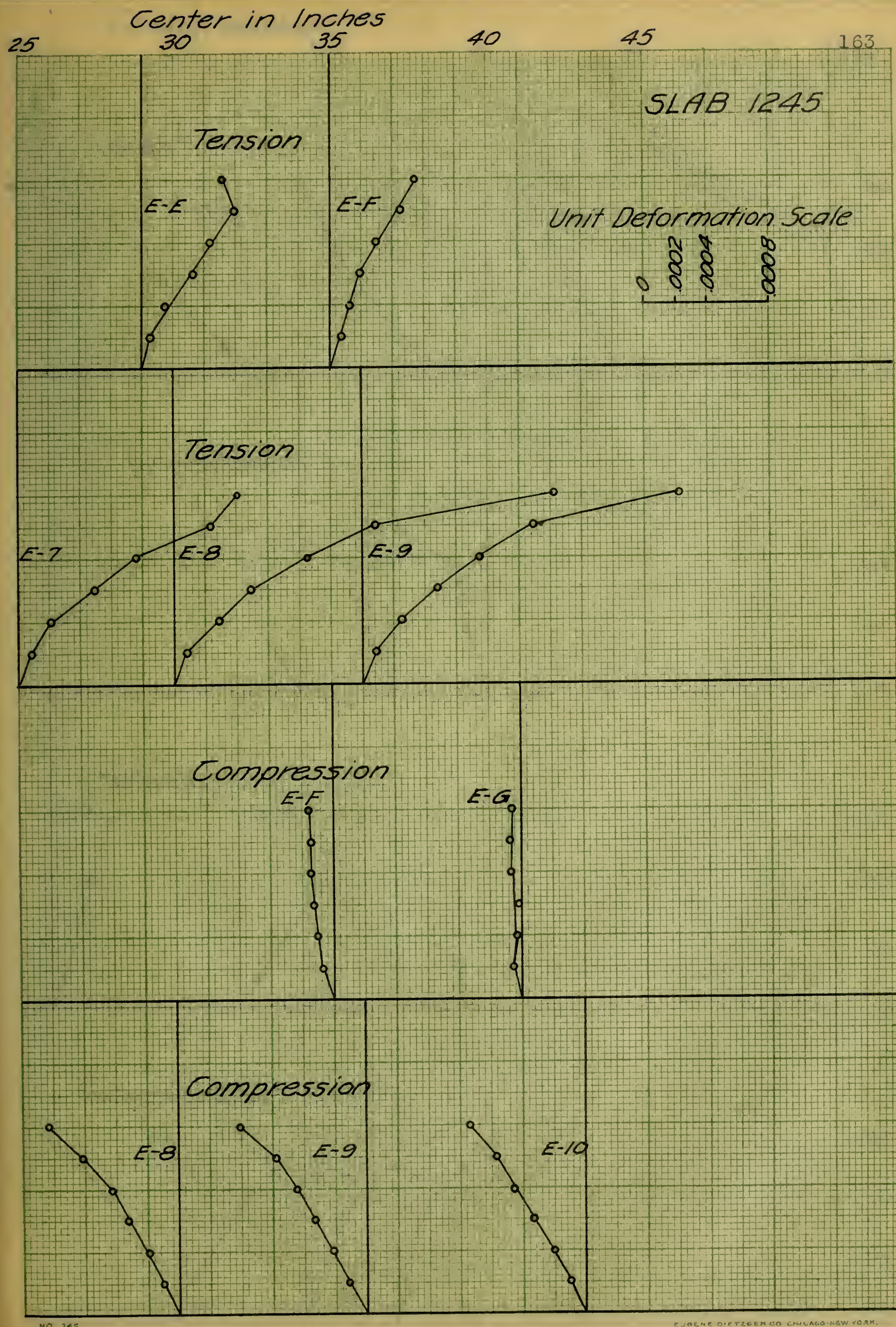
EUGENE DIETZGEN CO. CHICAGO NEW YORK

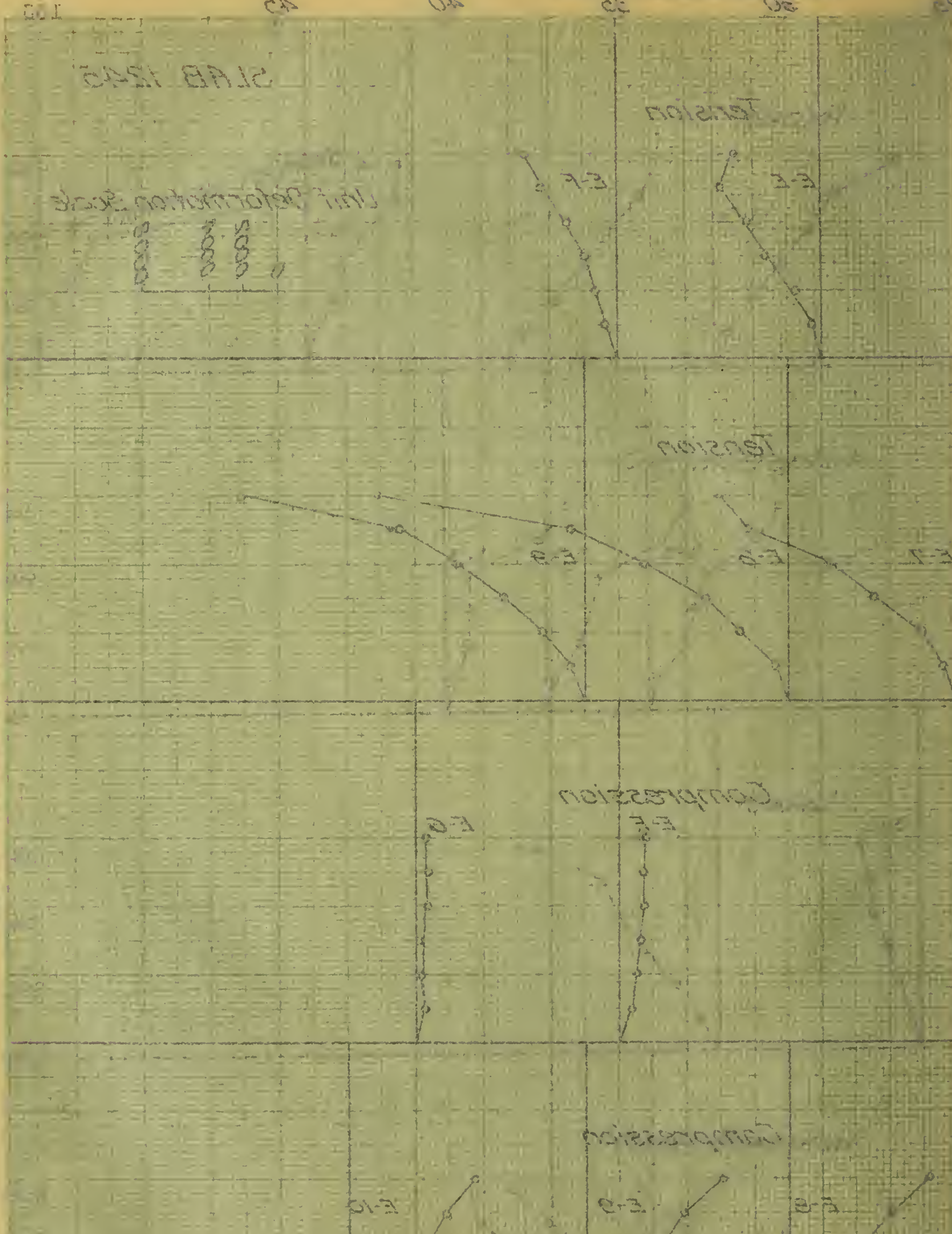

Center in inches
25
30
35
40
45
SLAB 12-45
Tension
Unit Deformation Scale
Tension
Compression
Compression



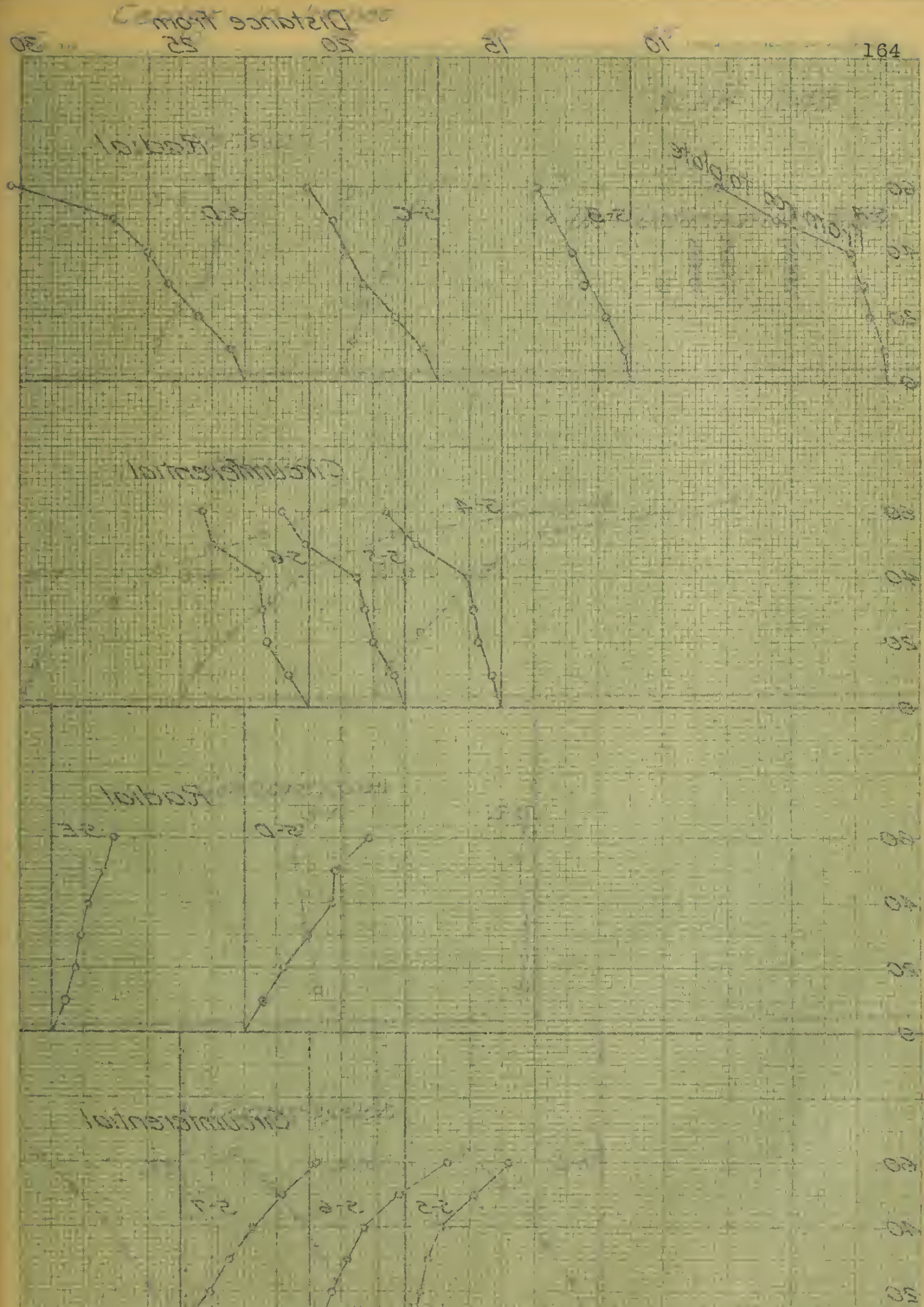


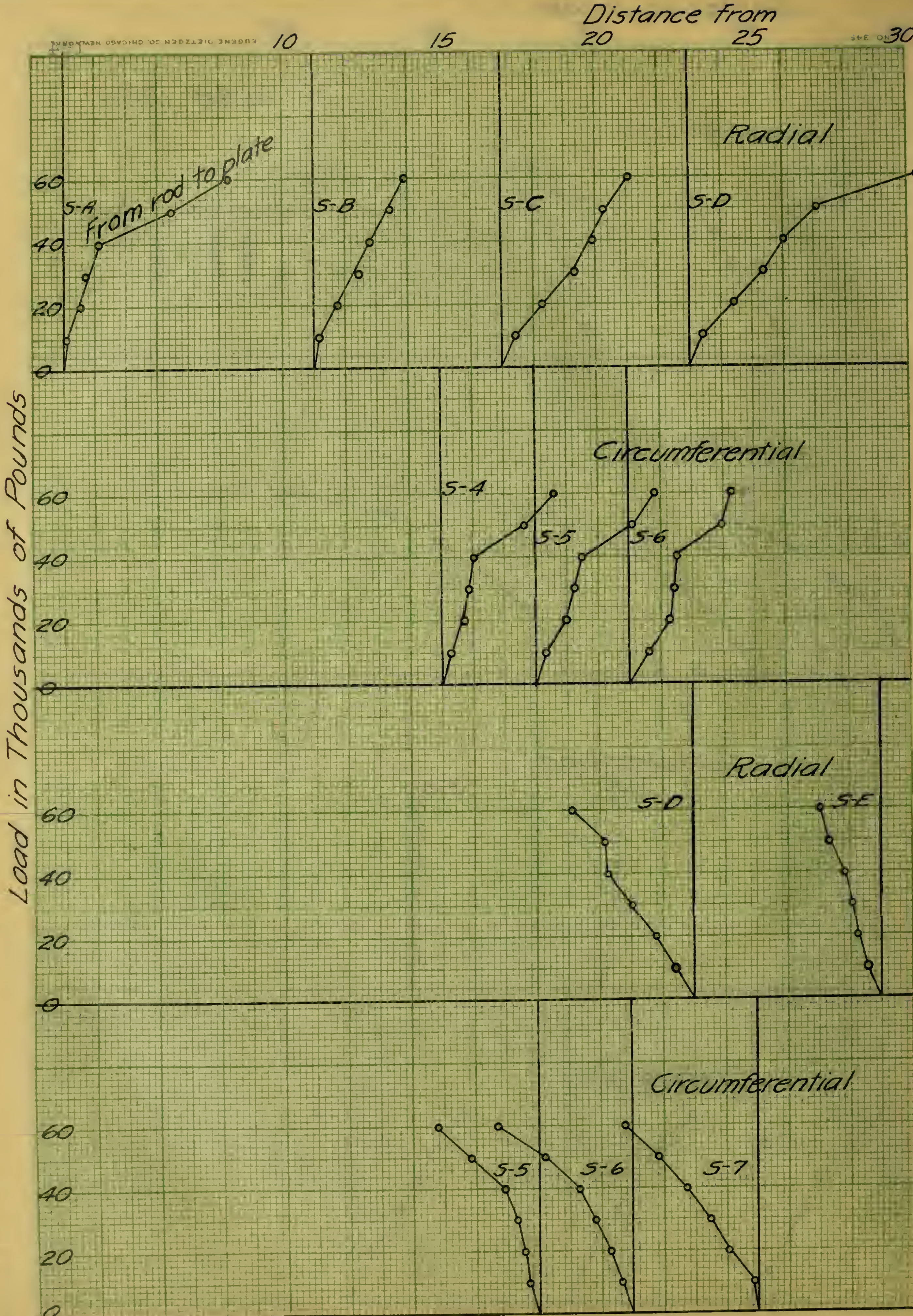
Distance from
10
15
20
25
30
Radial
Circumferential
Radial
Circumferential
From rod to plate
E-A
E-B
E-C
E-D
E-4
E-5
E-6
E-D
E-E
E-5
E-6
E-7
Load in Thousands of Pounds
0
20
40
60
EUGENE DIETZGEN CO. CHICAGO-NEW YORK
NO. 345

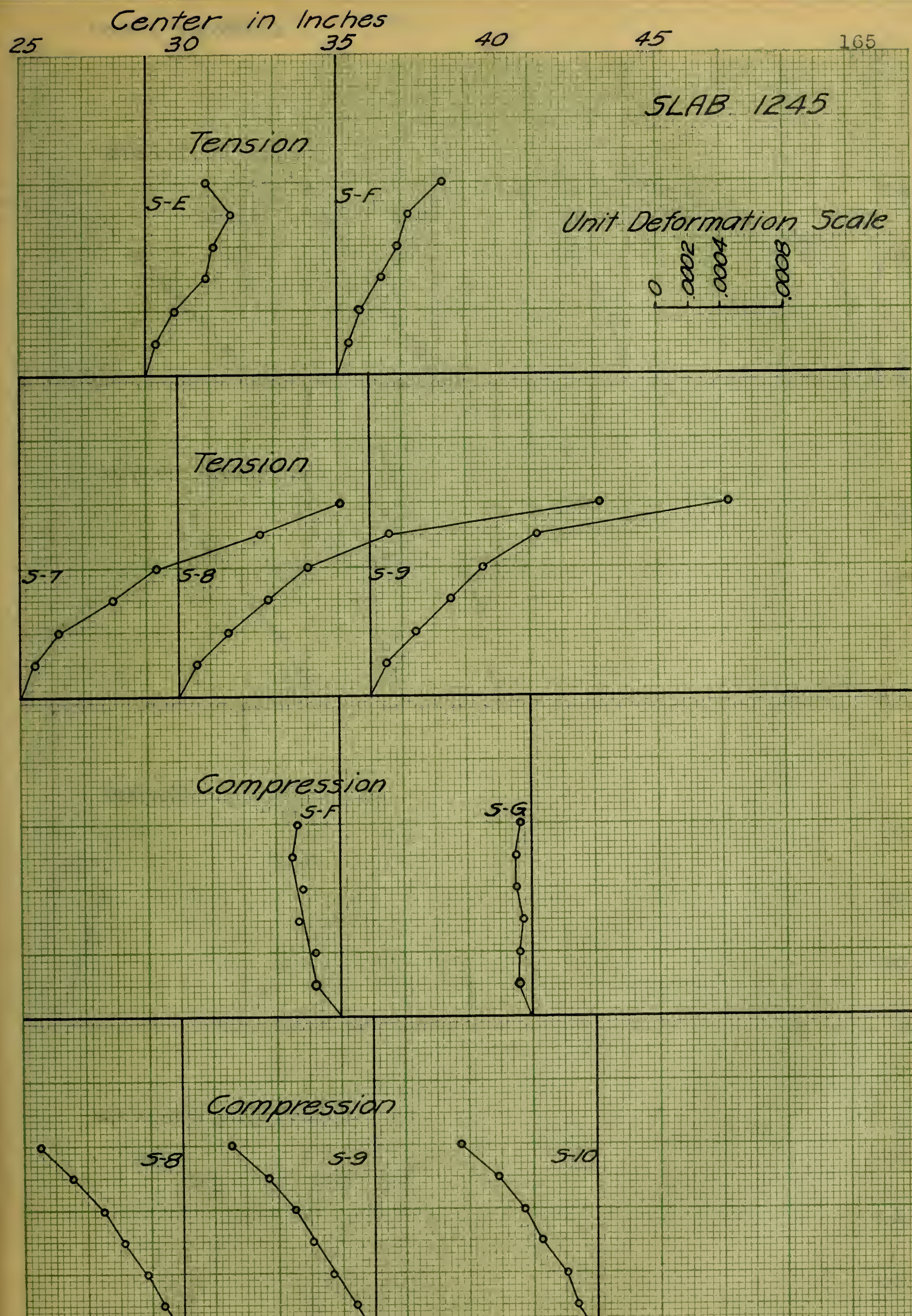

Center in Inches
25
30
35
40
45
SLAB 1245
Tension
E-E
E-F
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E-7
E-8
E-9
Compression
E-F
E-G
Compression
E-8
E-9
E-10
NO 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK.

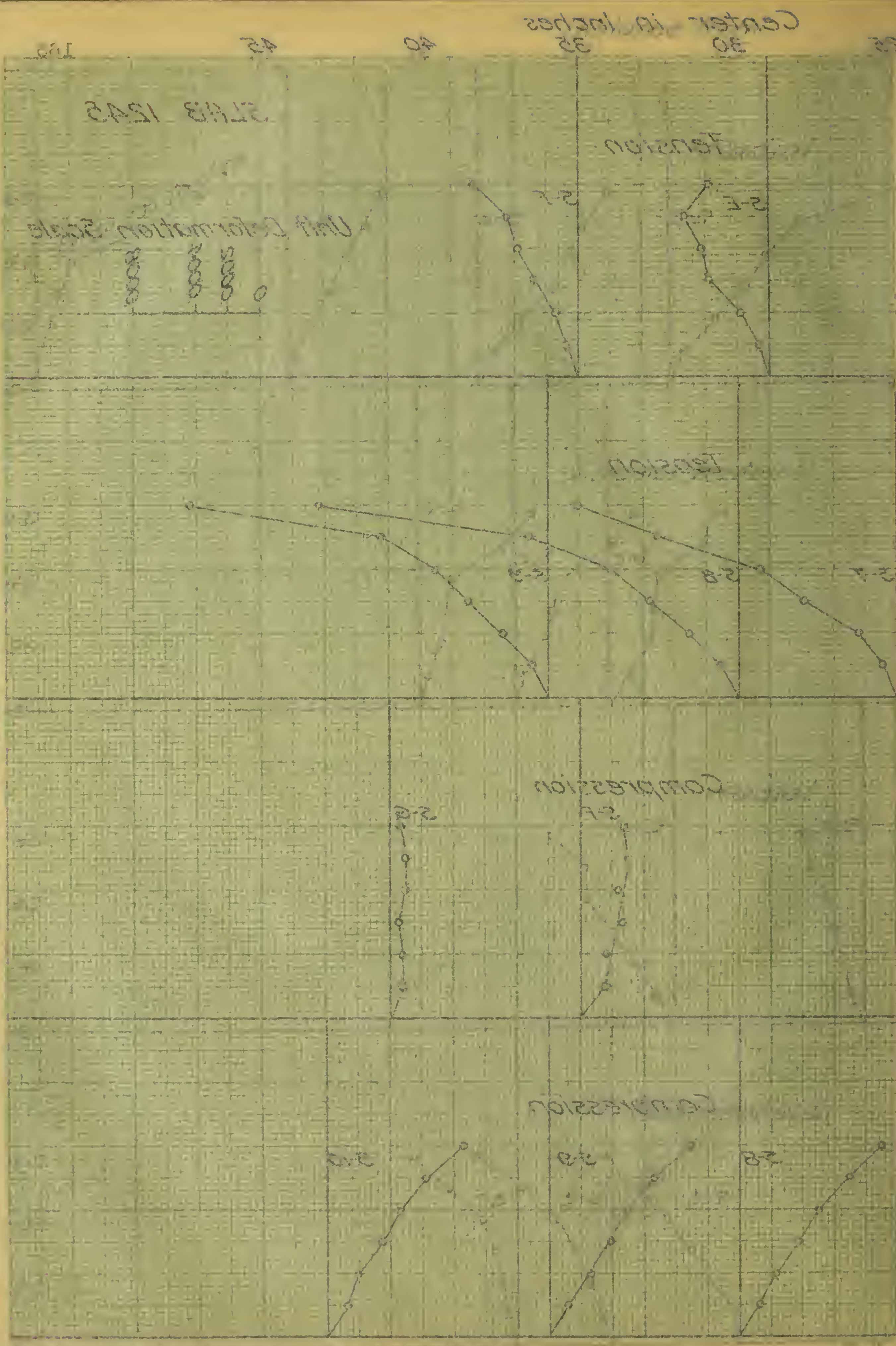


Center in Inches
25
30
35
40
45
SLAB 1245
Unit Deformation Scale
Tension
Compression
E-1
E-2
E-3
E-4
E-5
E-6
E-7
E-8
E-9
E-10

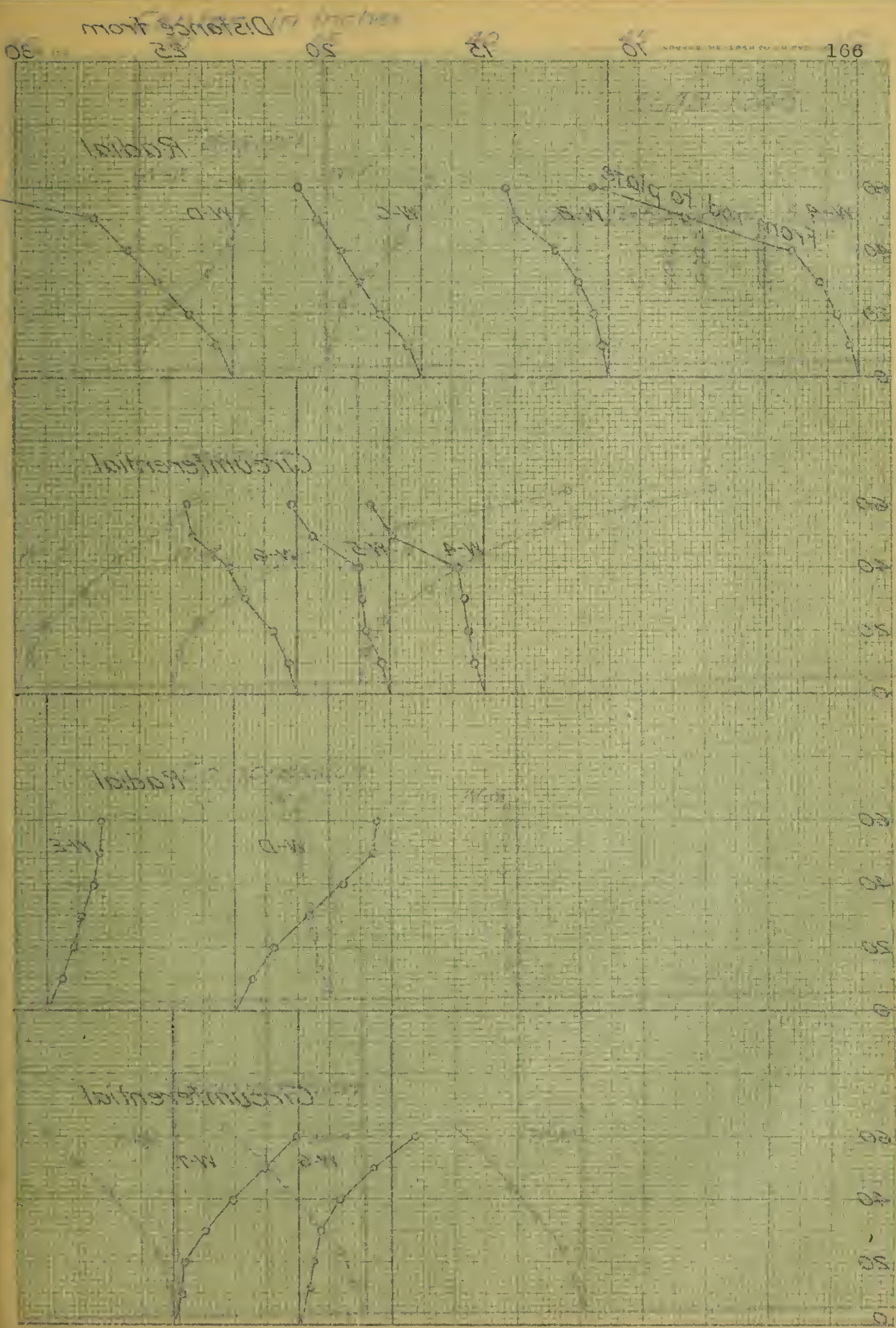

Distance from Center of plate
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

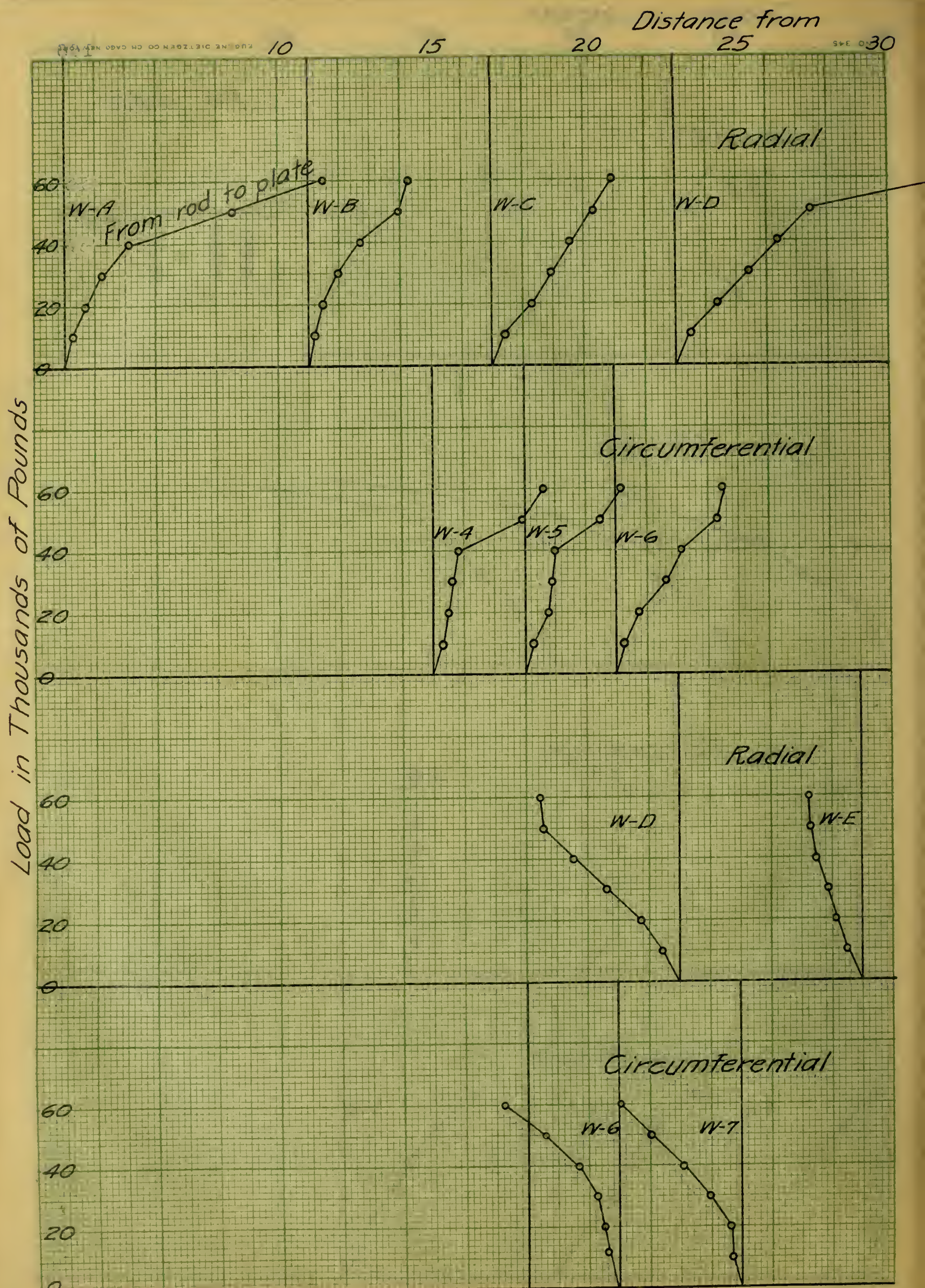

Distance from
10
15
20
25
30
Radial
S-A
From rod to plate
S-B
S-C
S-D
Circumferential
S-4
S-5
S-6
Radial
S-D
S-E
Circumferential
S-5
S-6
S-7
Load in Thousands of Pounds
0
20
40
60


Center in Inches
25
30
35
40
45
SLAB 1245
Tension
5-E
5-F
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
5-7
5-8
5-9
Compression
5-F
5-G
Compression
5-8
5-9
5-10

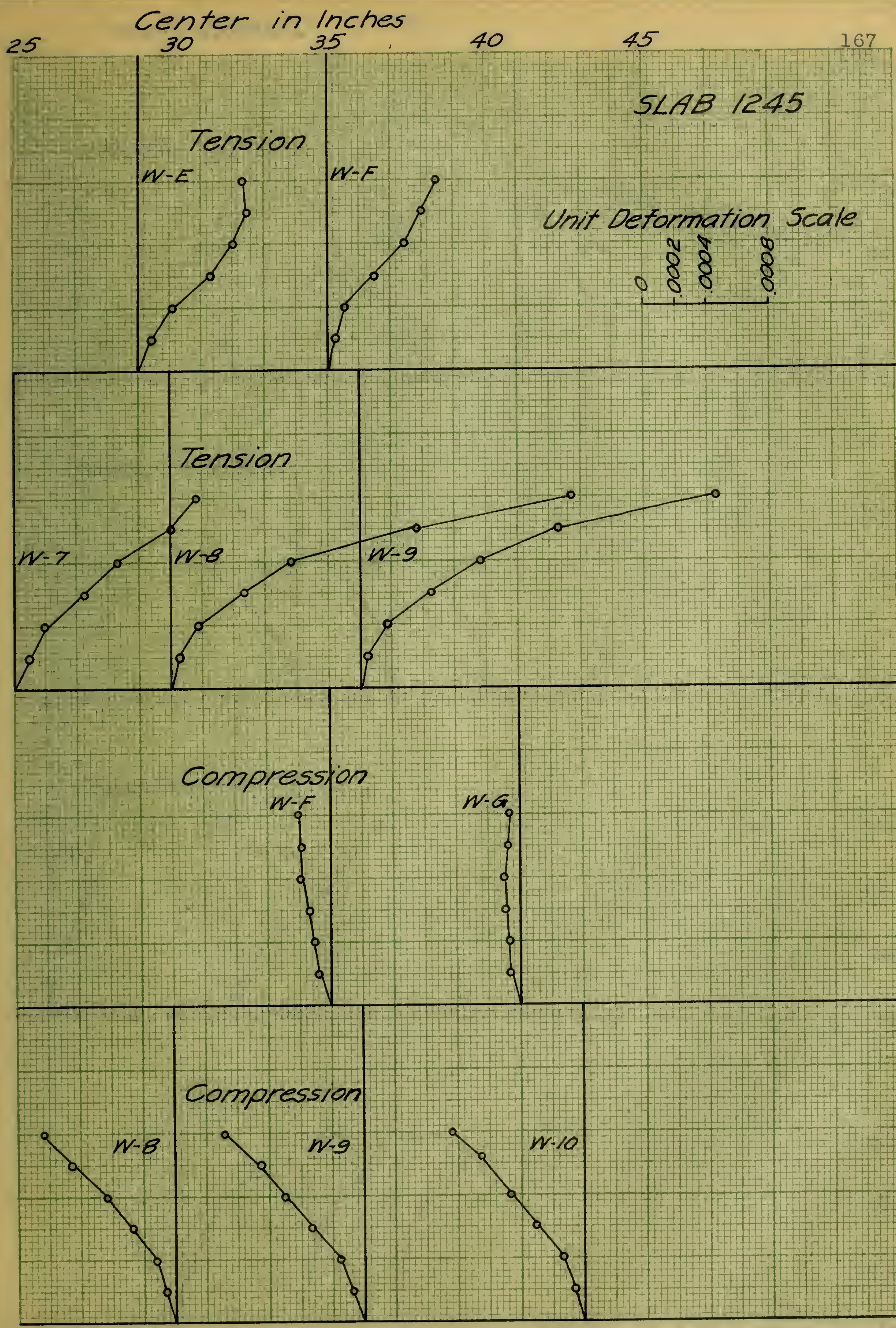


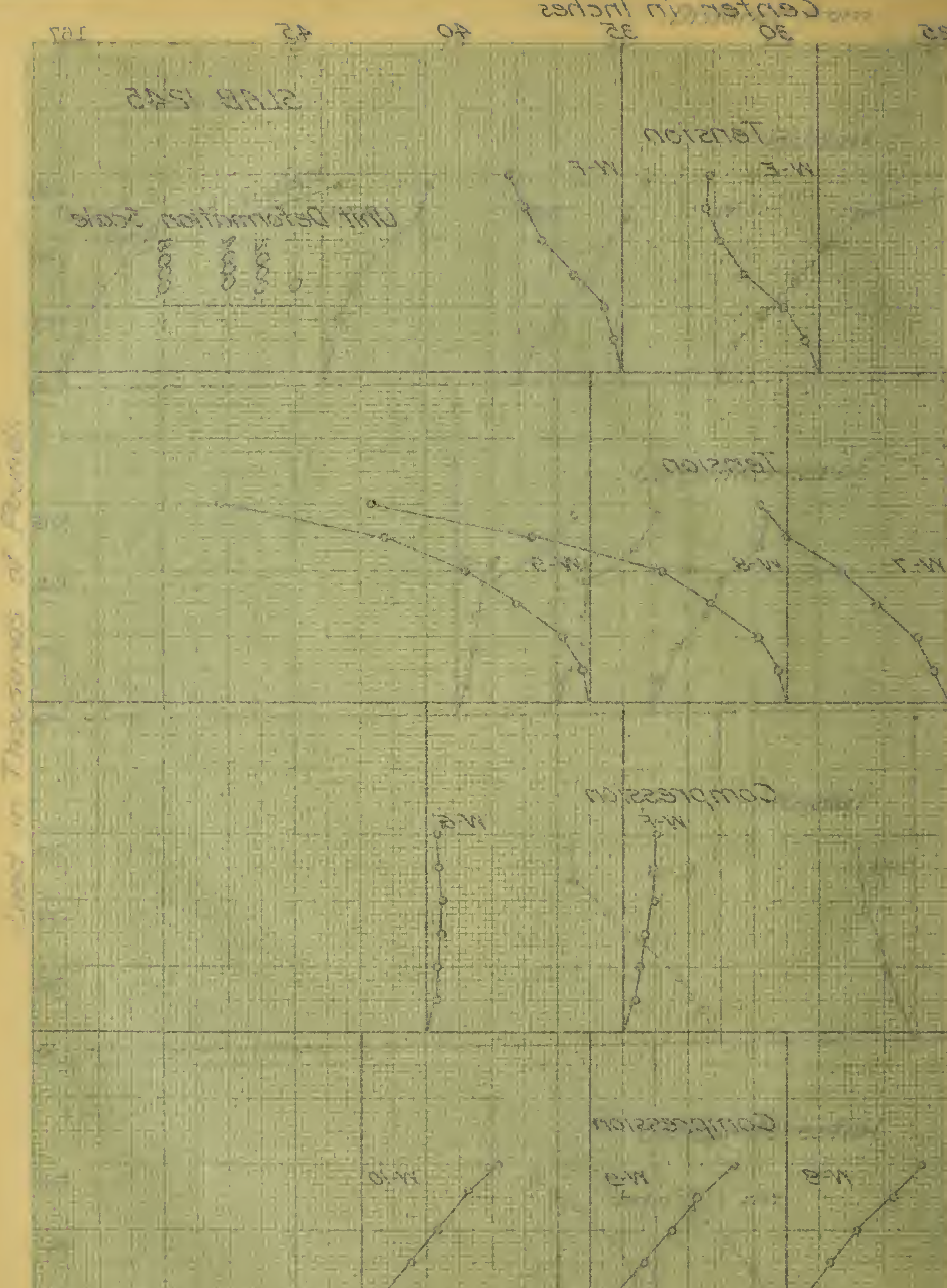
Center in Inches
25
30
35
40
45
SLAB 1245
Tension
Unit Deformation Scale
Tension
Compression
Compression

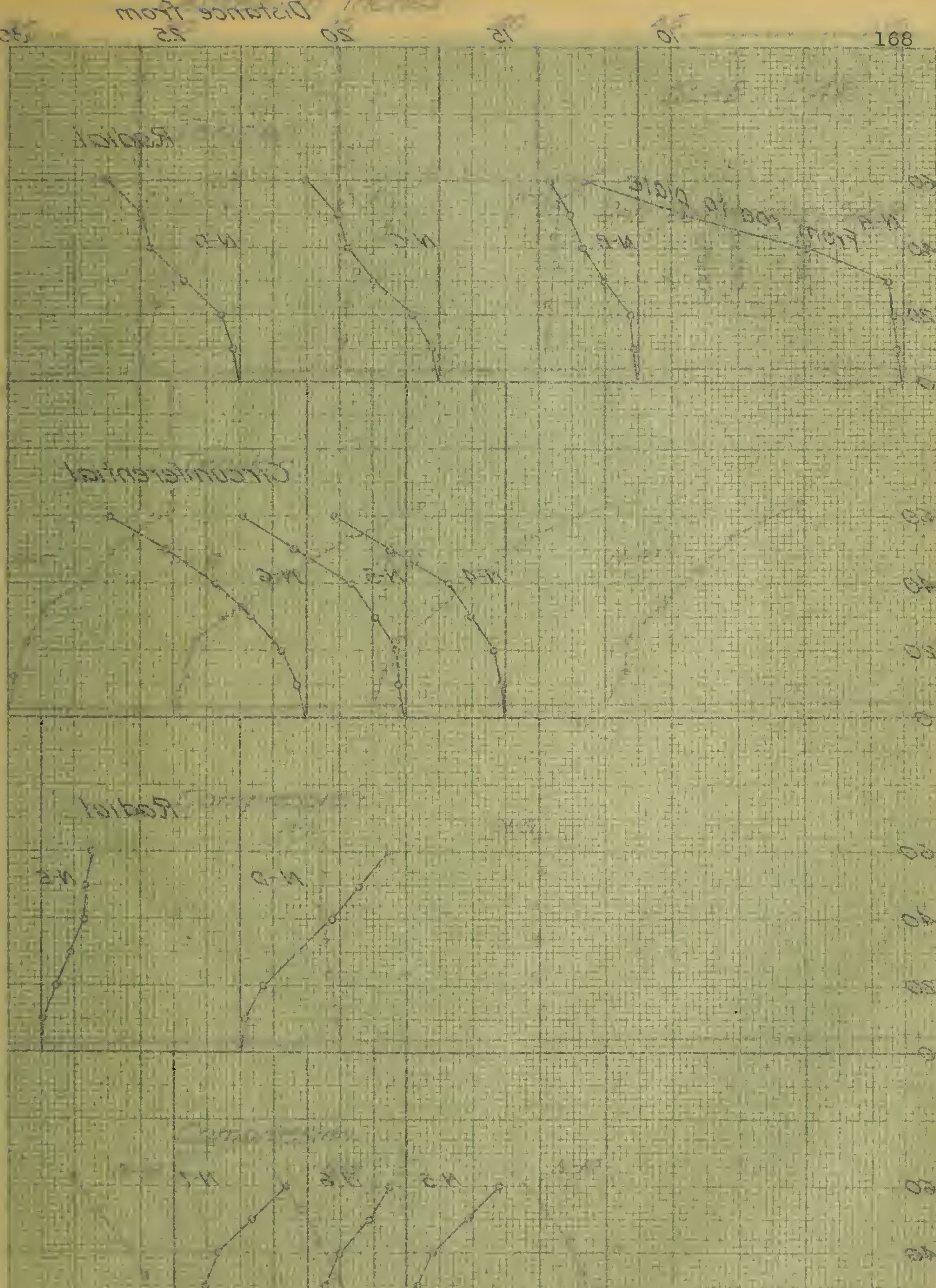

Distance from
30
25
20
15
10
Radial
Circumferential
Radial
Circumferential
from rod to plate
Load in Thousands of Pounds



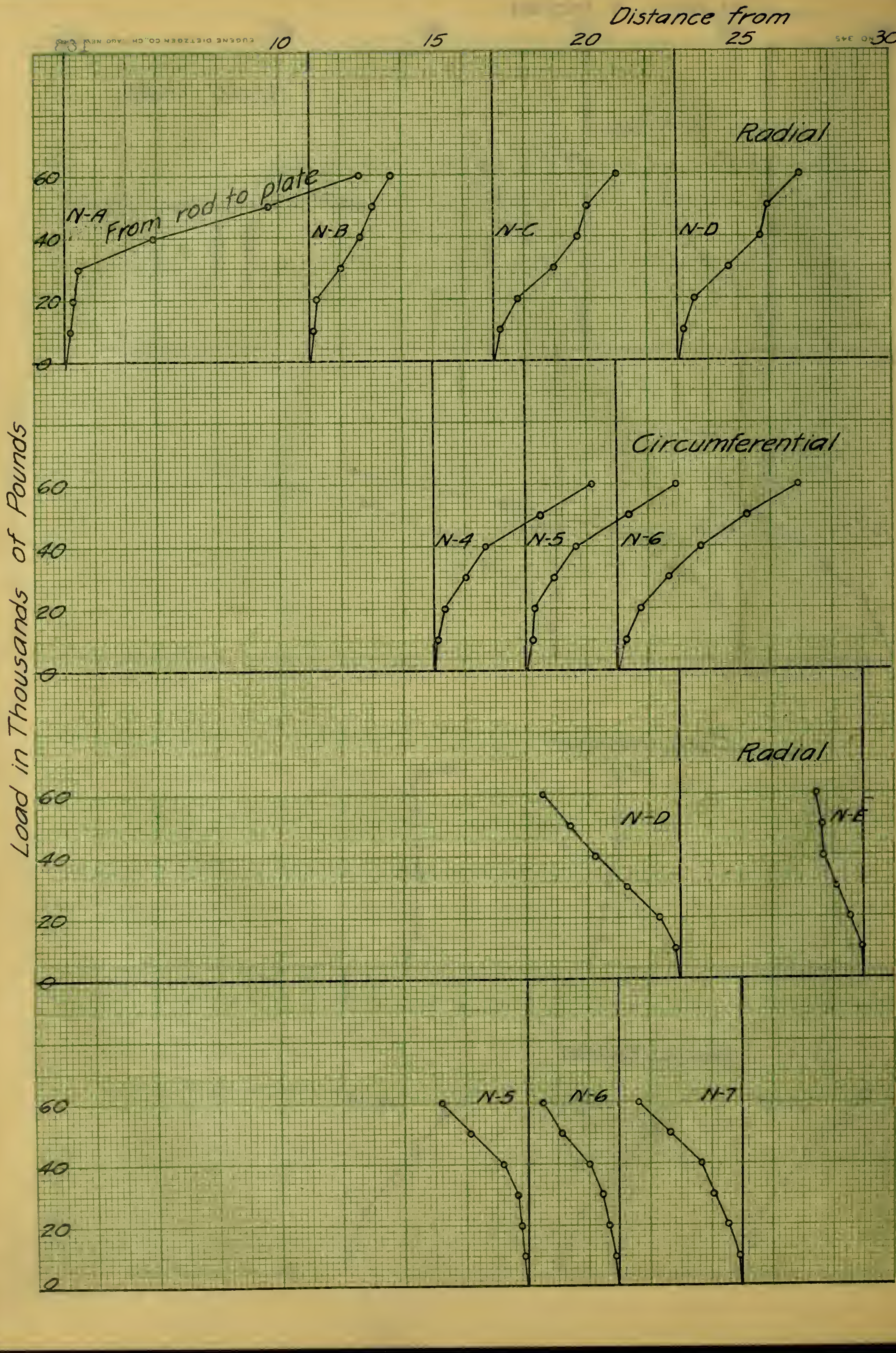
Distance from
10
15
20
25
30
Radial
W-A
From rod to plate
W-B
W-C
W-D
Circumferential
W-4
W-5
W-6
Radial
W-D
W-E
Circumferential
W-6
W-7
Load in Thousands of Pounds
60
40
20
0


Center in Inches
25
30
35
40
45
SLAB 1245
Tension
W-E
W-F
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
W-7
W-8
W-9
Compression
W-F
W-G
Compression
W-8
W-9
W-10
NO 345

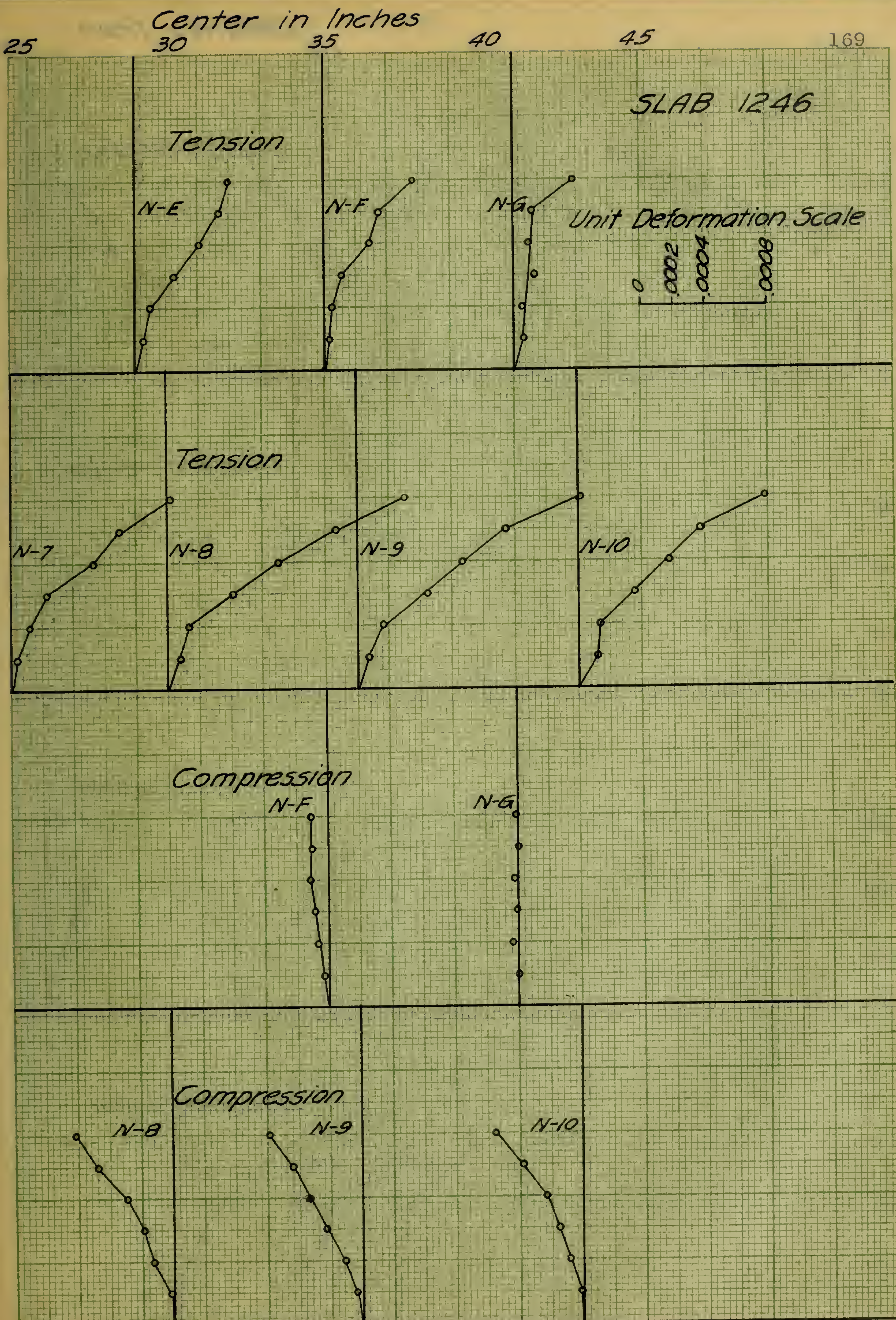

Center in inches
Tension
Tension
Compression
Compression
Unit Deformation Scale

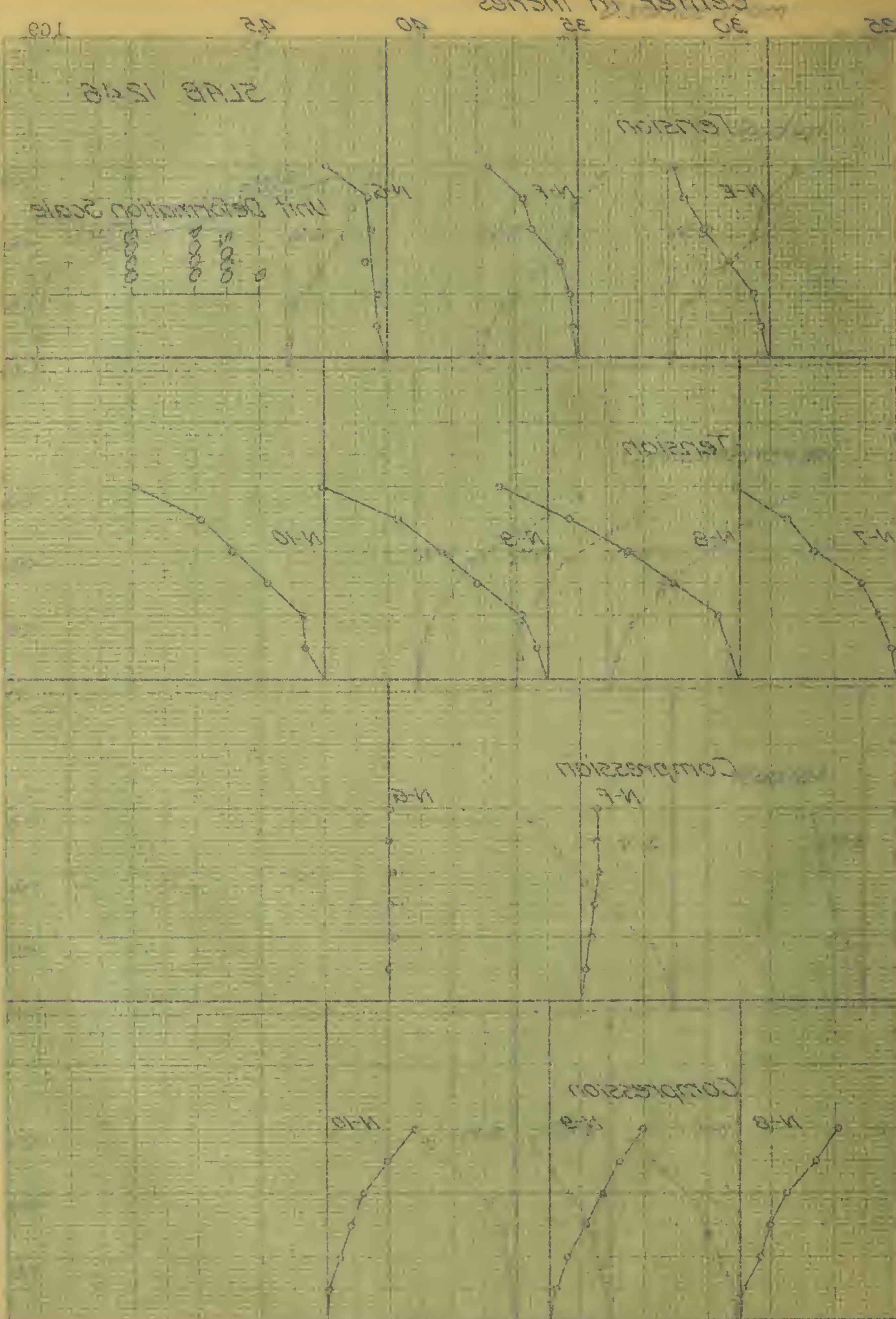


Distance from
Load in Thousands of Pounds
Radial
Circumferential
Radial

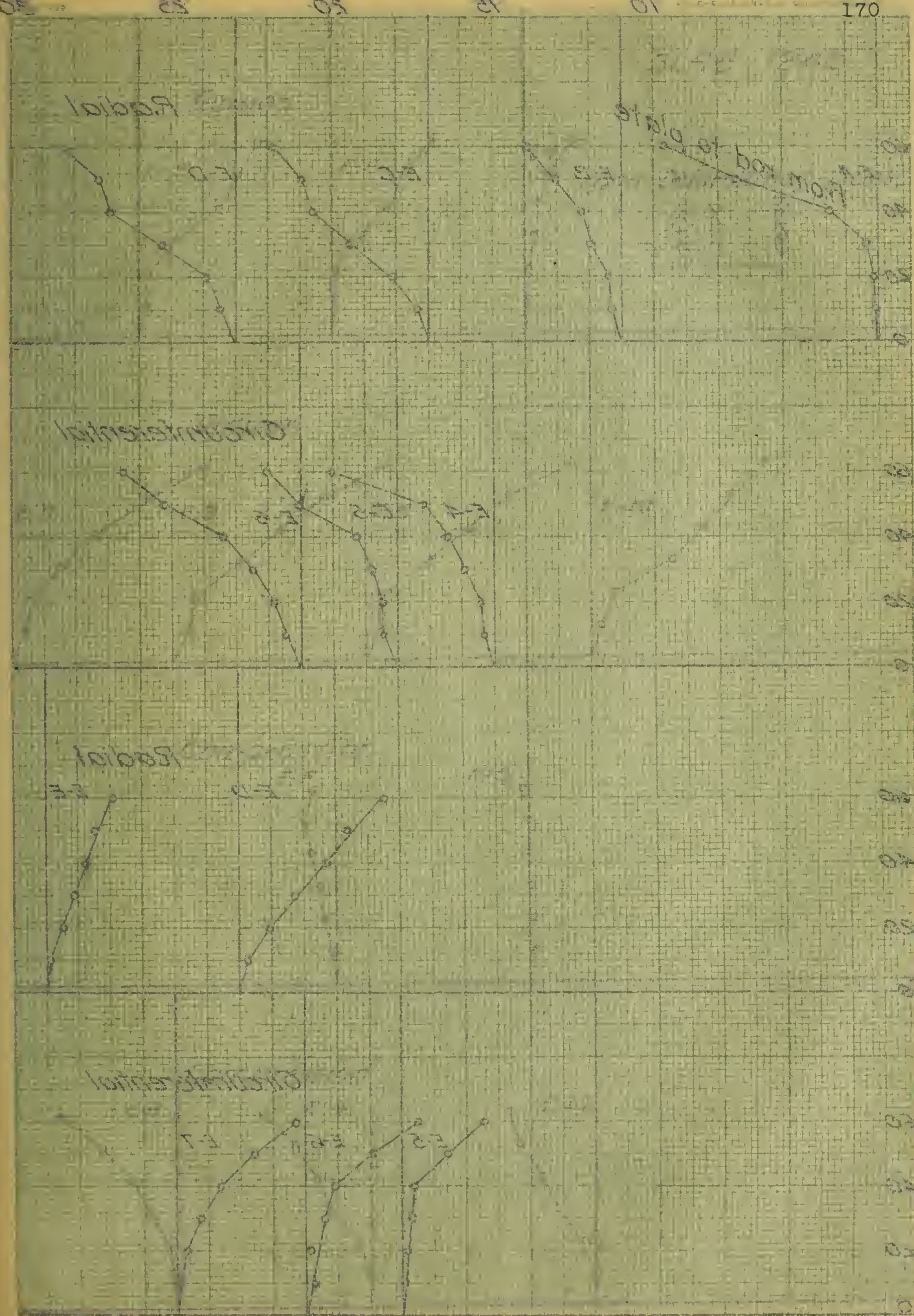


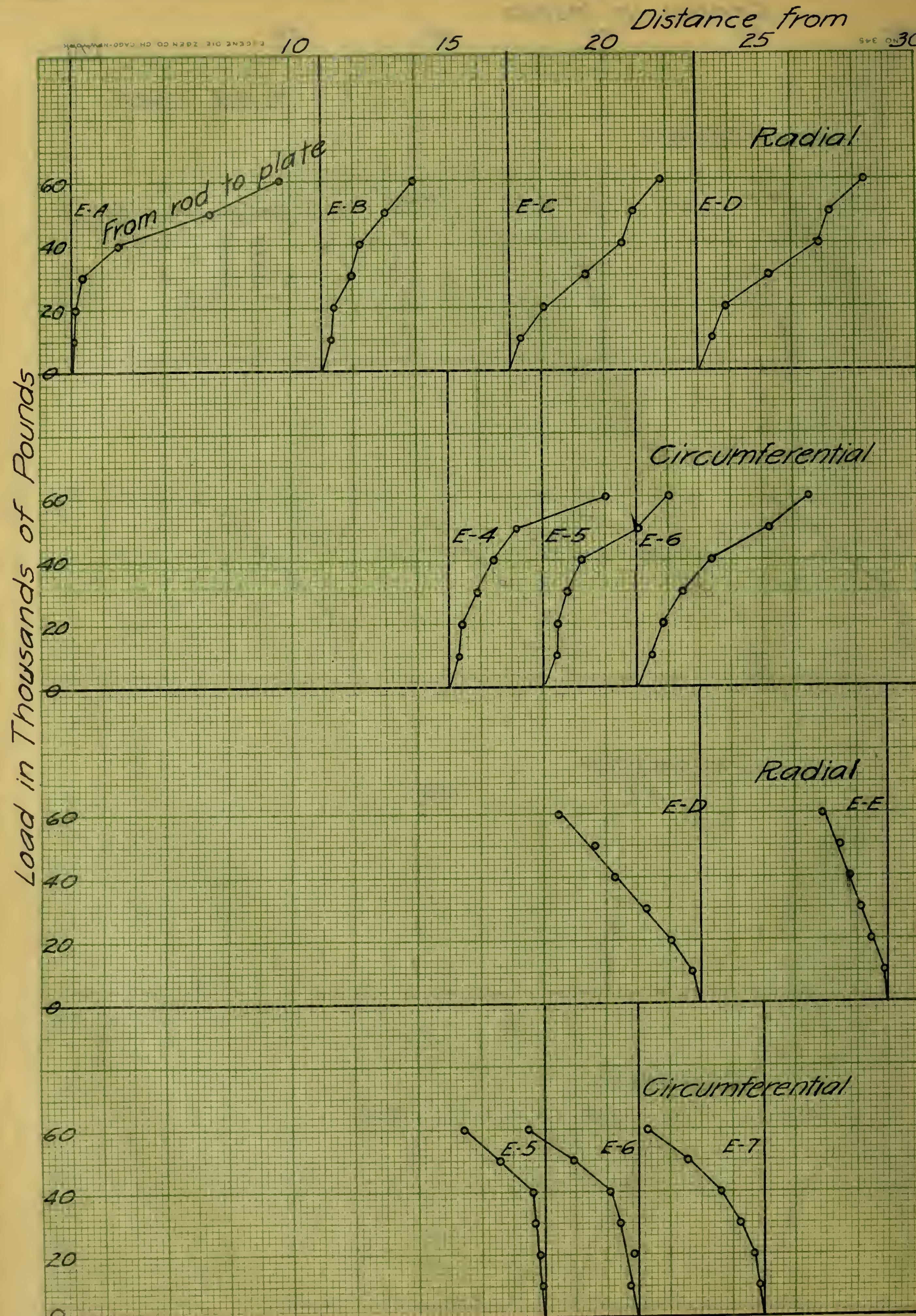
Distance from
10
15
20
25
30
Radial
N-A
From rod to plate
N-B
N-C
N-D
Circumferential
N-4
N-5
N-6
Radial
N-D
N-E
N-5
N-6
N-7
Load in Thousands of Pounds
60
40
20
0


Center in Inches
25
30
35
40
45
SLAB 1246
Tension
N-E
N-F
N-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
N-7
N-8
N-9
N-10
Compression
N-F
N-G
Compression
N-8
N-9
N-10

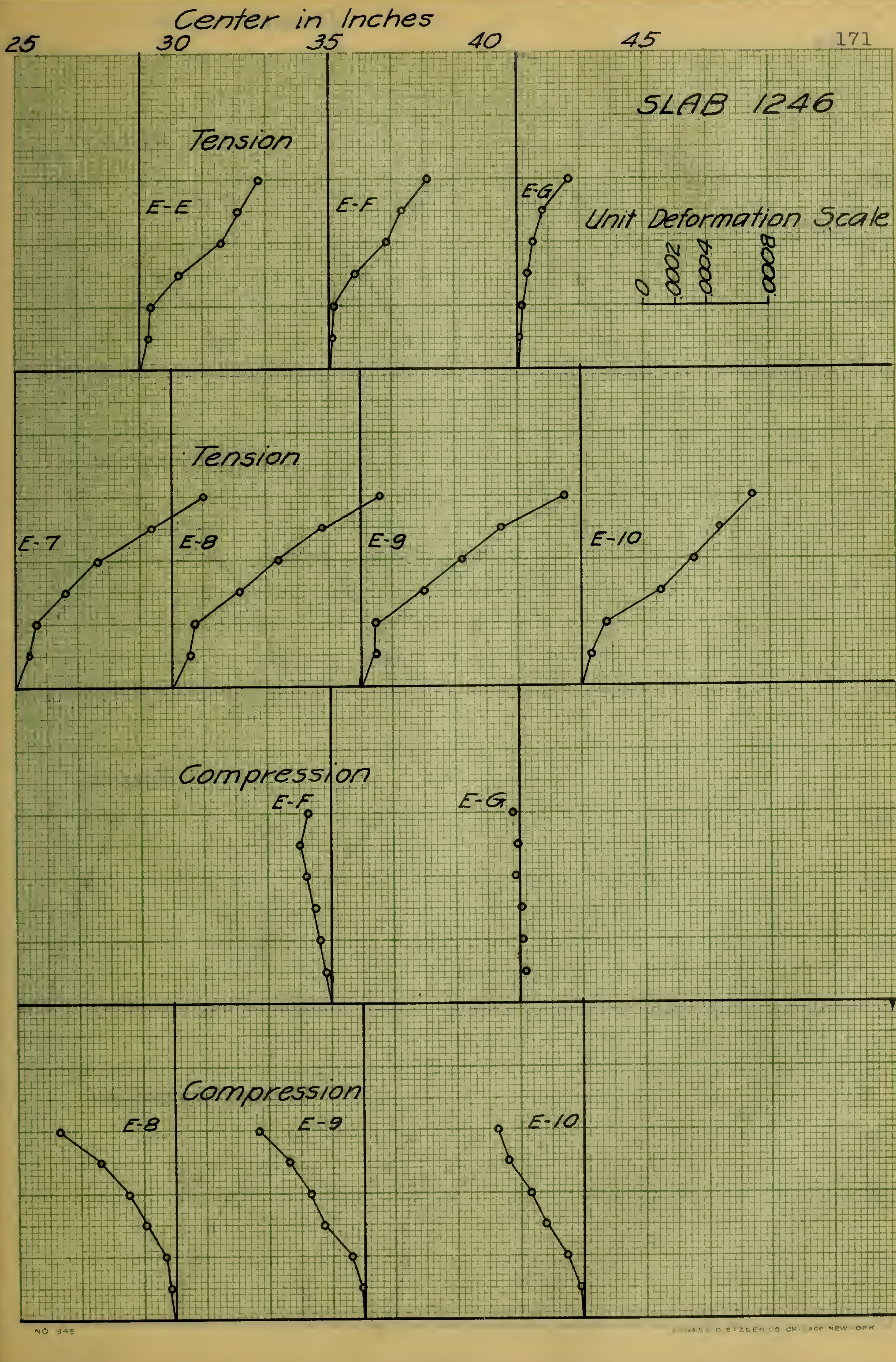


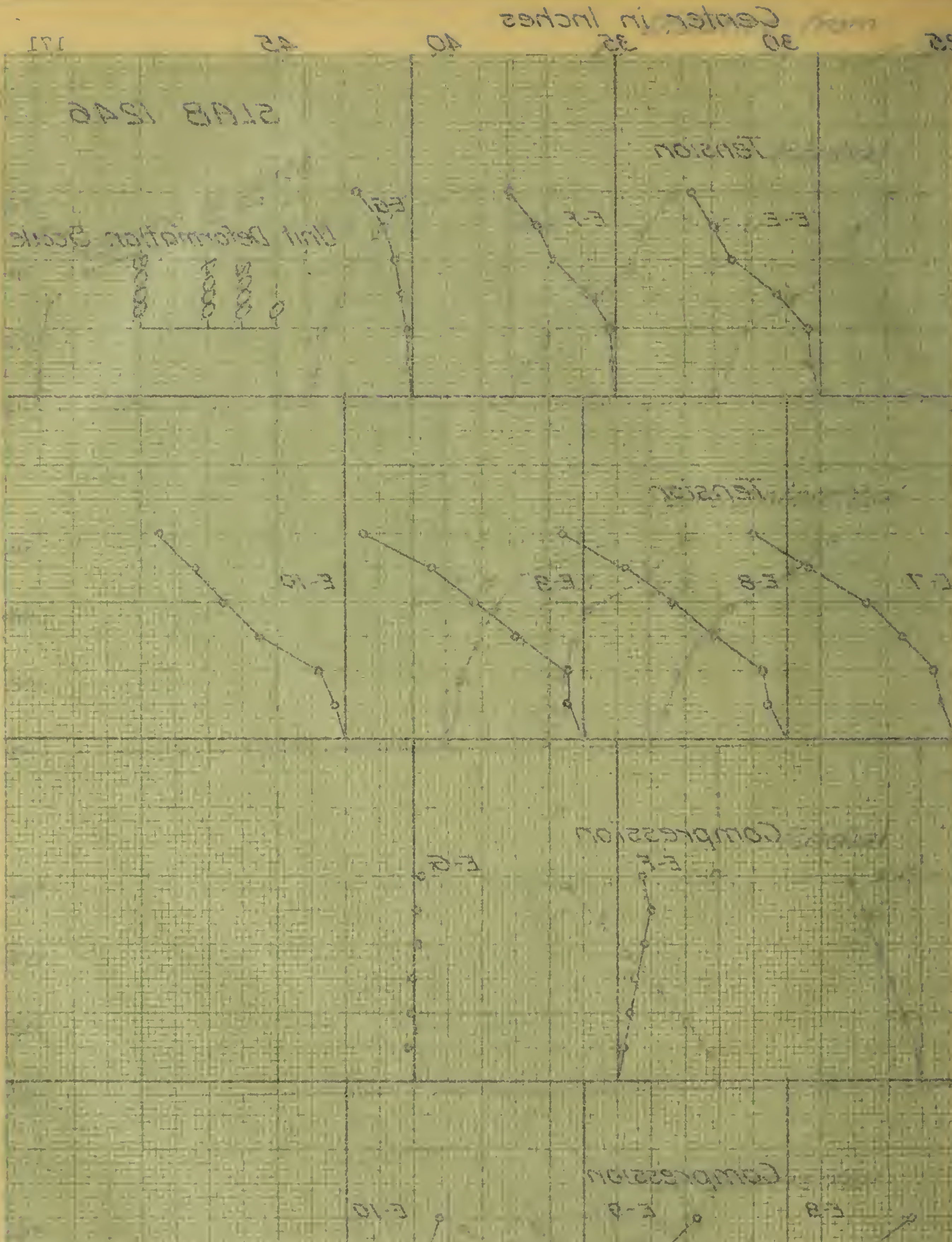
Center in Inches
25
30
35
40
45
109
SLAB 1246
Unit Deformation Scale
Tension
N-5
N-6
N-7
N-8
N-9
N-10
Compression
Load in Thousands of Pounds


Distance from Center in Inches
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

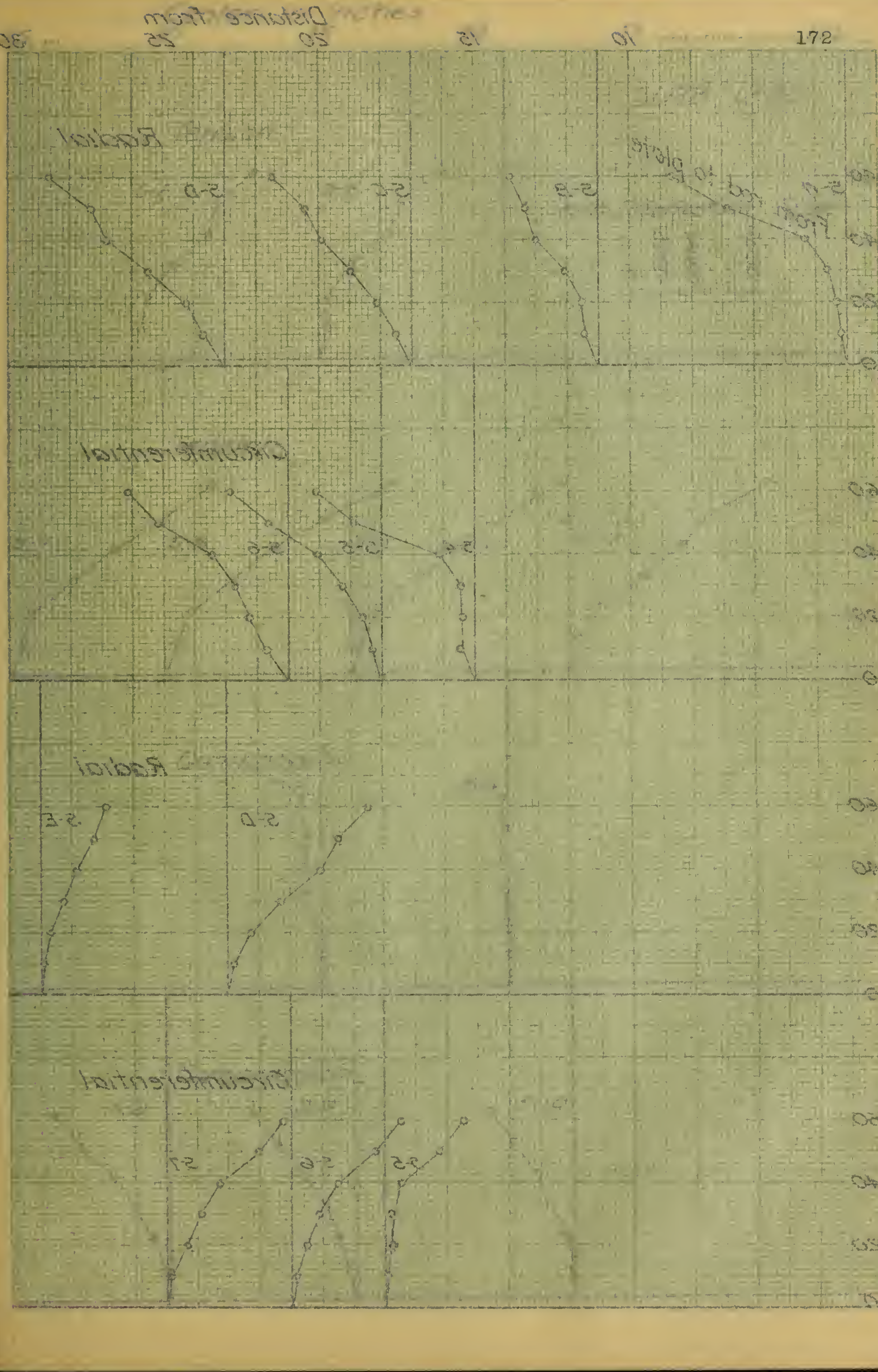


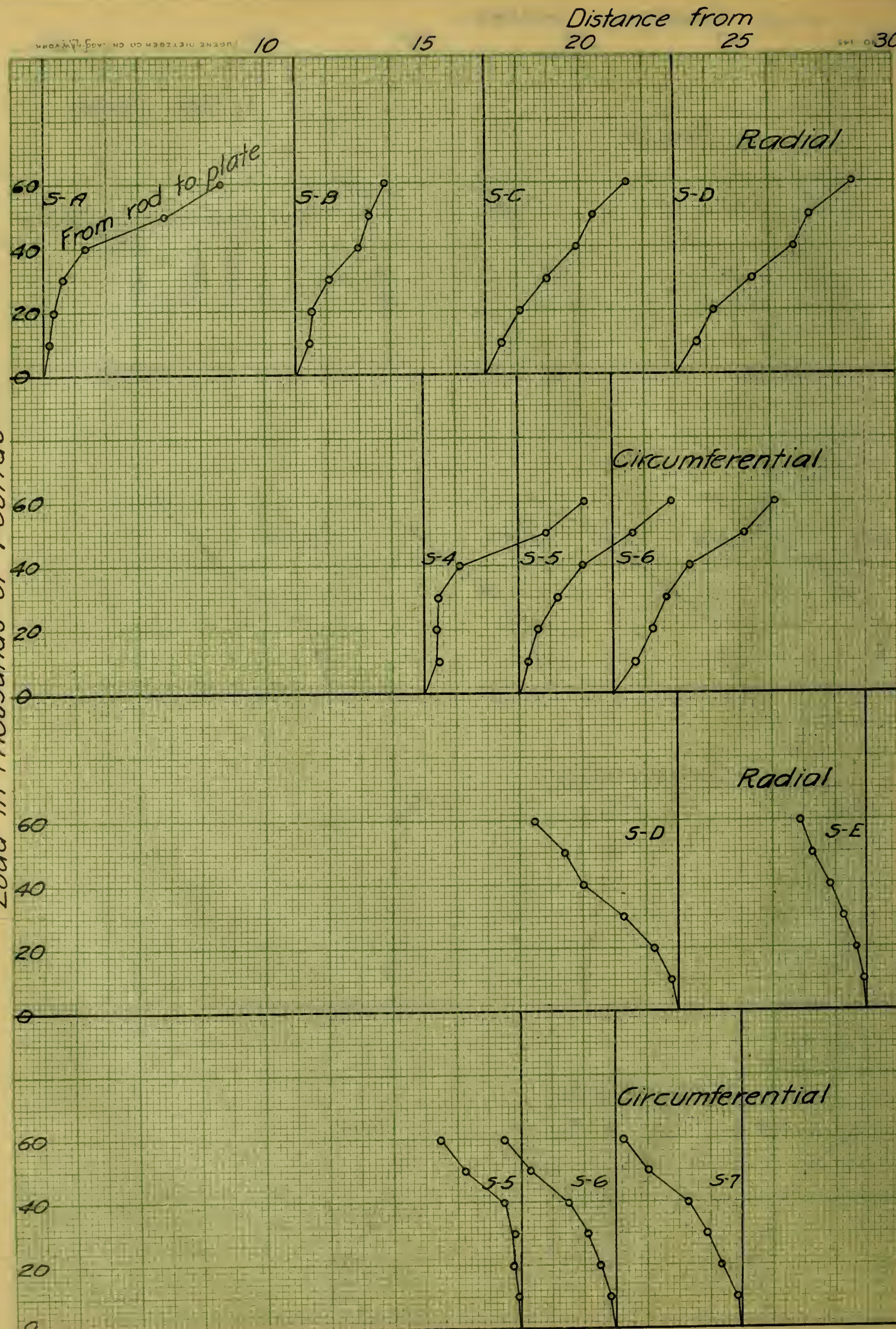
Distance from
10
15
20
25
30
Load in Thousands of Pounds
0
20
40
60
From rod to plate
E-A
E-B
E-C
E-D
Radial
Circumferential
E-4
E-5
E-6
Radial
E-D
E-E
Circumferential
E-5
E-6
E-7


Center in Inches
25
30
35
40
45
SLAB 1246
Tension
E-E
E-F
E-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E-7
E-8
E-9
E-10
Compression
E-F
E-G
Compression
E-8
E-9
E-10

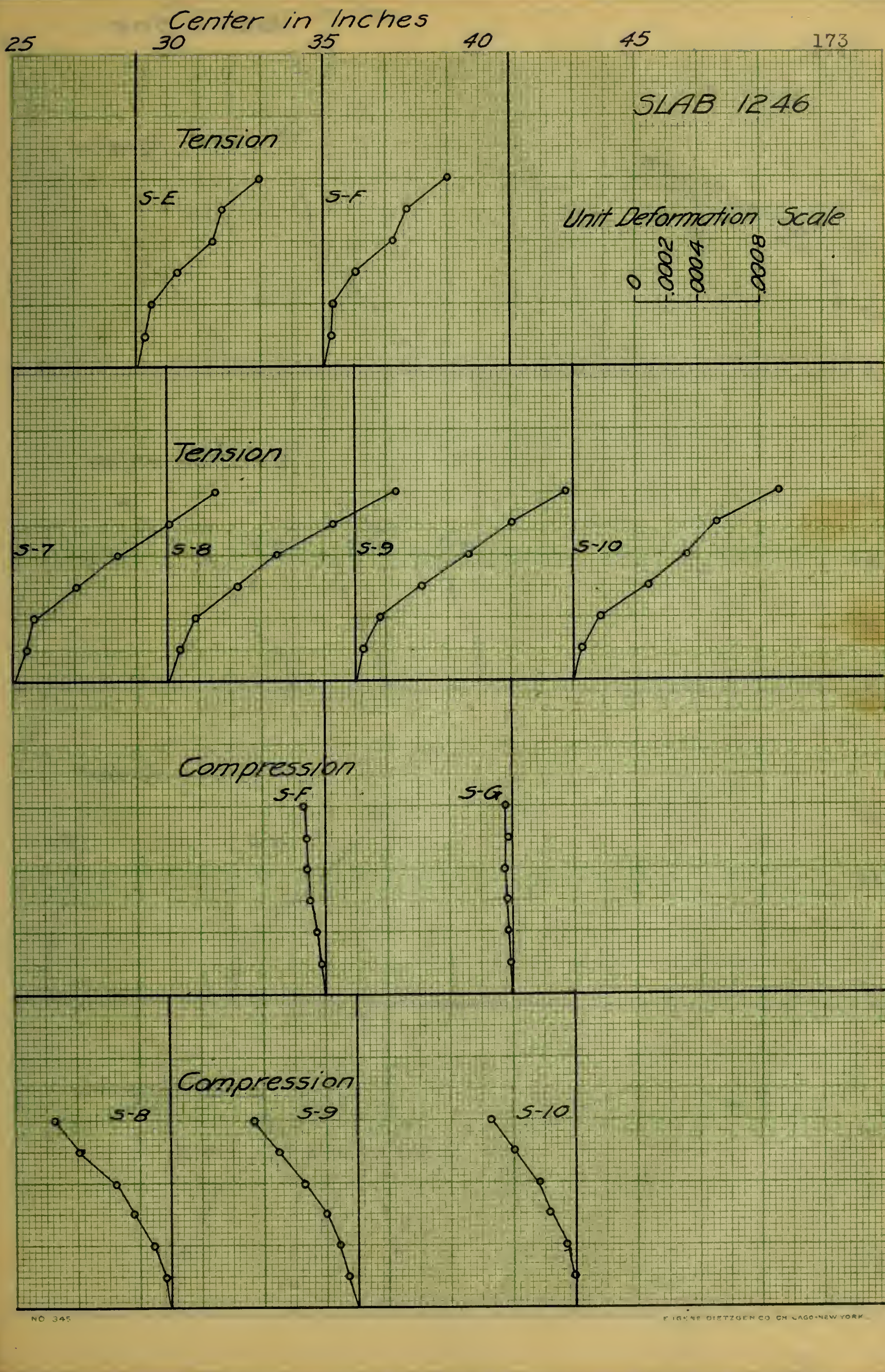


SLAB 1246
Unit Deformation Scale
Center in Inches
Load in Thousands of Pounds
Tension
Compression
E-5
E-6
E-7
E-8
E-9
E-10

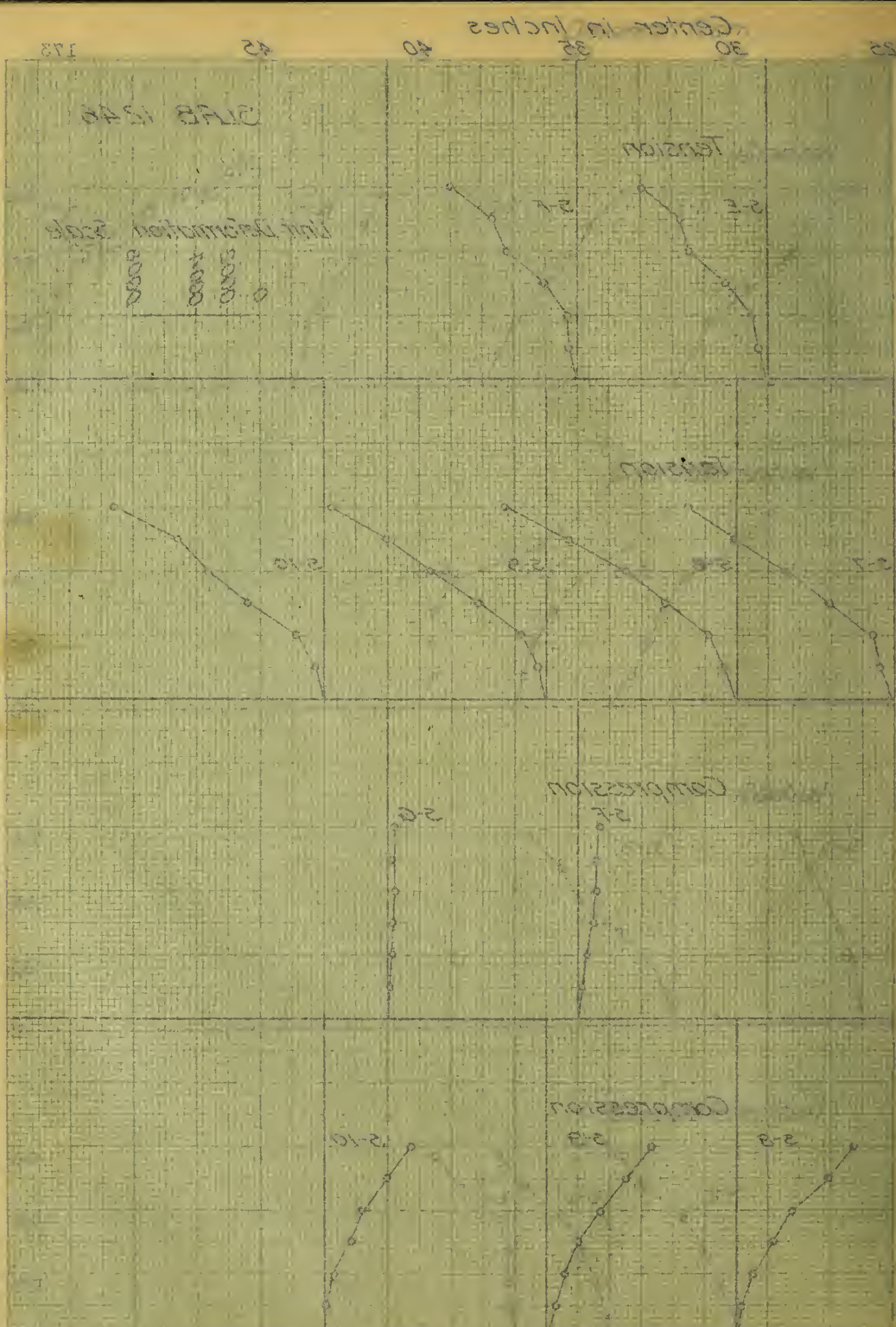

Distance from
Radial
Circumferential
Radial
Circumferential
Load in Thousands of Pounds
S-D
S-E
S-5
S-6
S-7

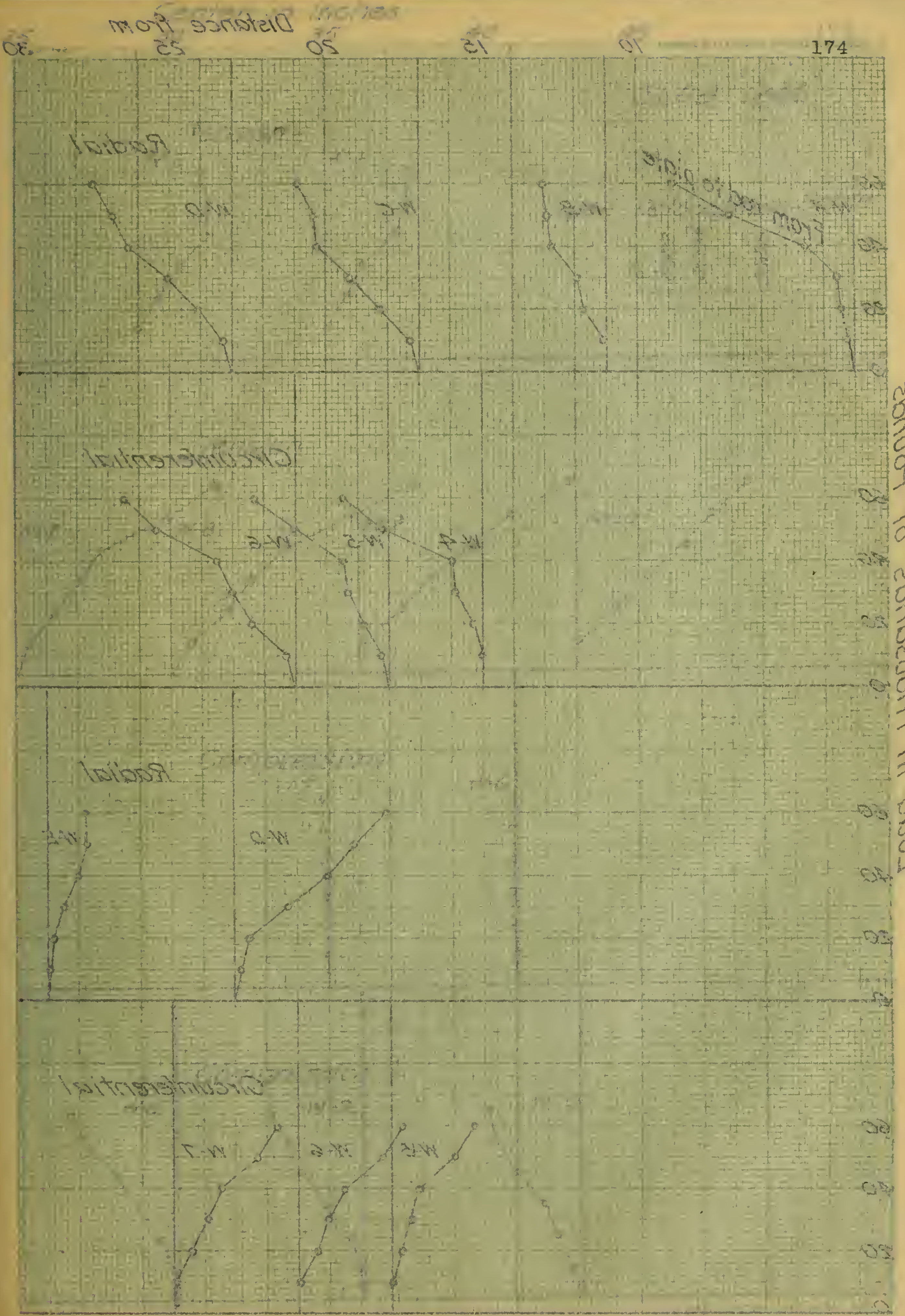


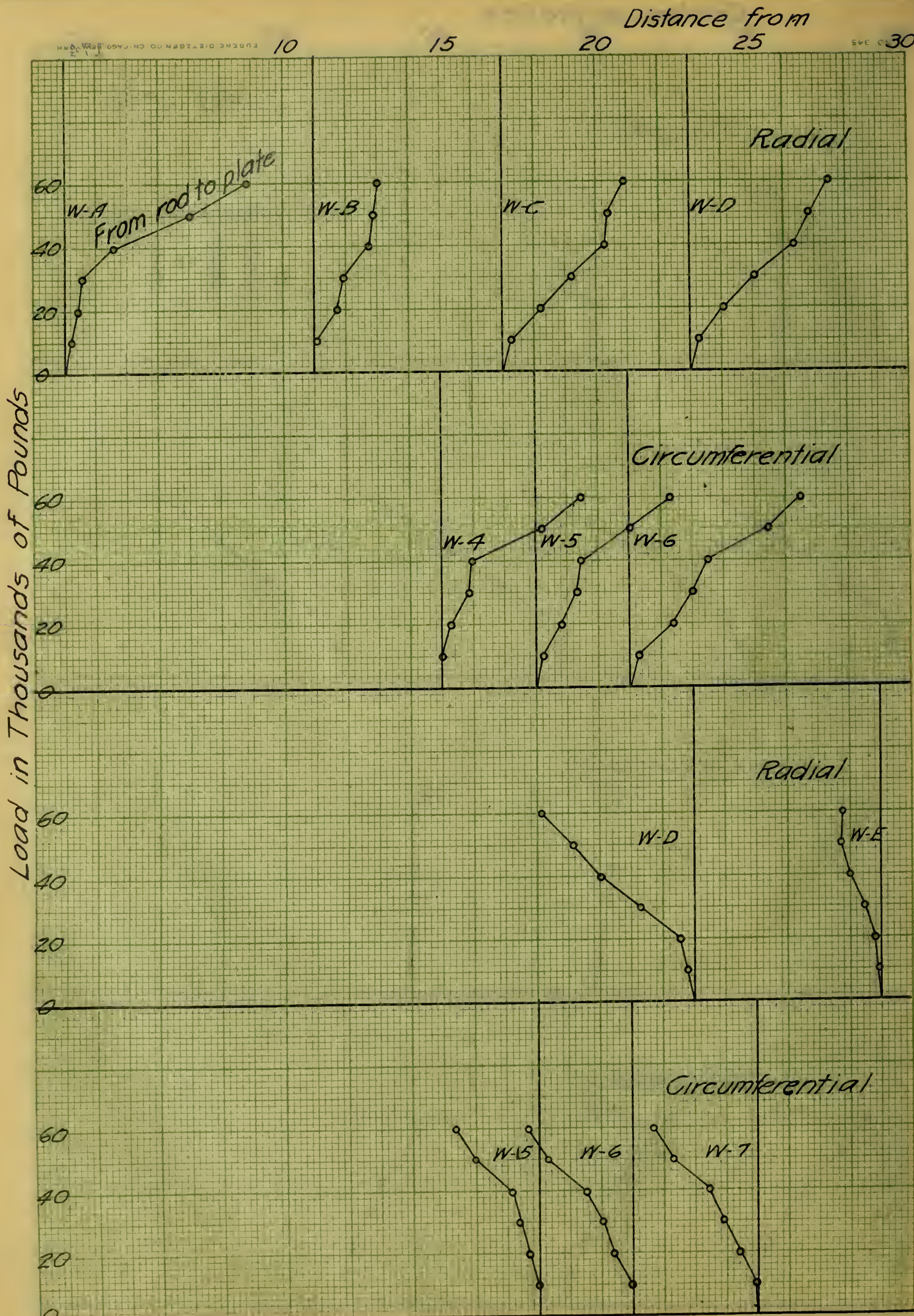
Distance from
10
15
20
25
30
Load in Thousands of Pounds
From rod to plate
Radial
S-A
S-B
S-C
S-D
Circumferential
S-4
S-5
S-6
Radial
S-D
S-E
Circumferential
S-5
S-6
S-7
0
20
40
60



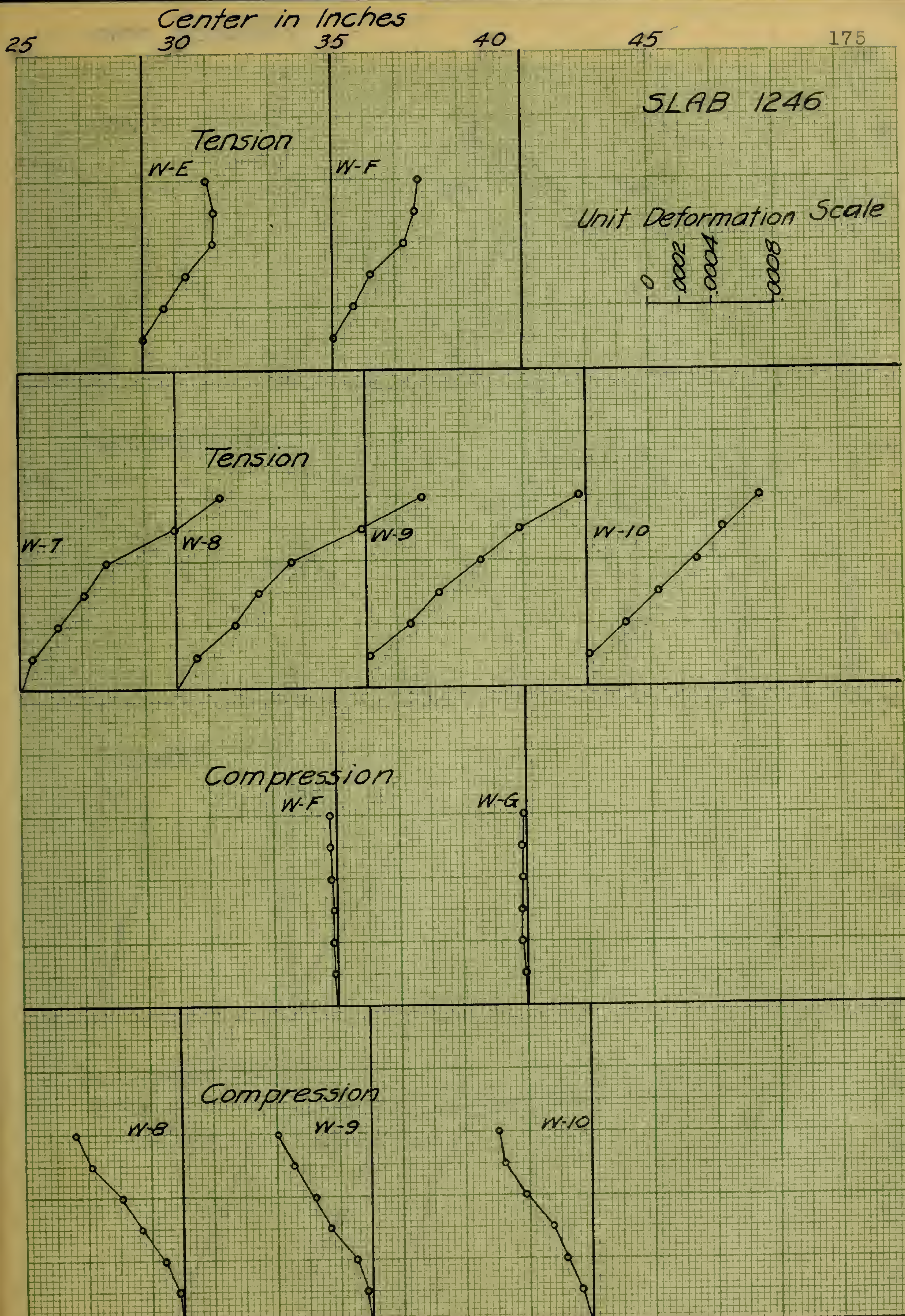
Center in Inches
25
30
35
40
45
SLAB 1246
Tension
S-E
S-F
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
S-7
S-8
S-9
S-10
Compression
S-F
S-G
Compression
S-8
S-9
S-10


Center in Inches
Tension
Tension
Compression
Compression
Unit Deformation Scale


Distance from
Radial
Circumferential
Radial
Circumferential
Load in Thousands of Pounds

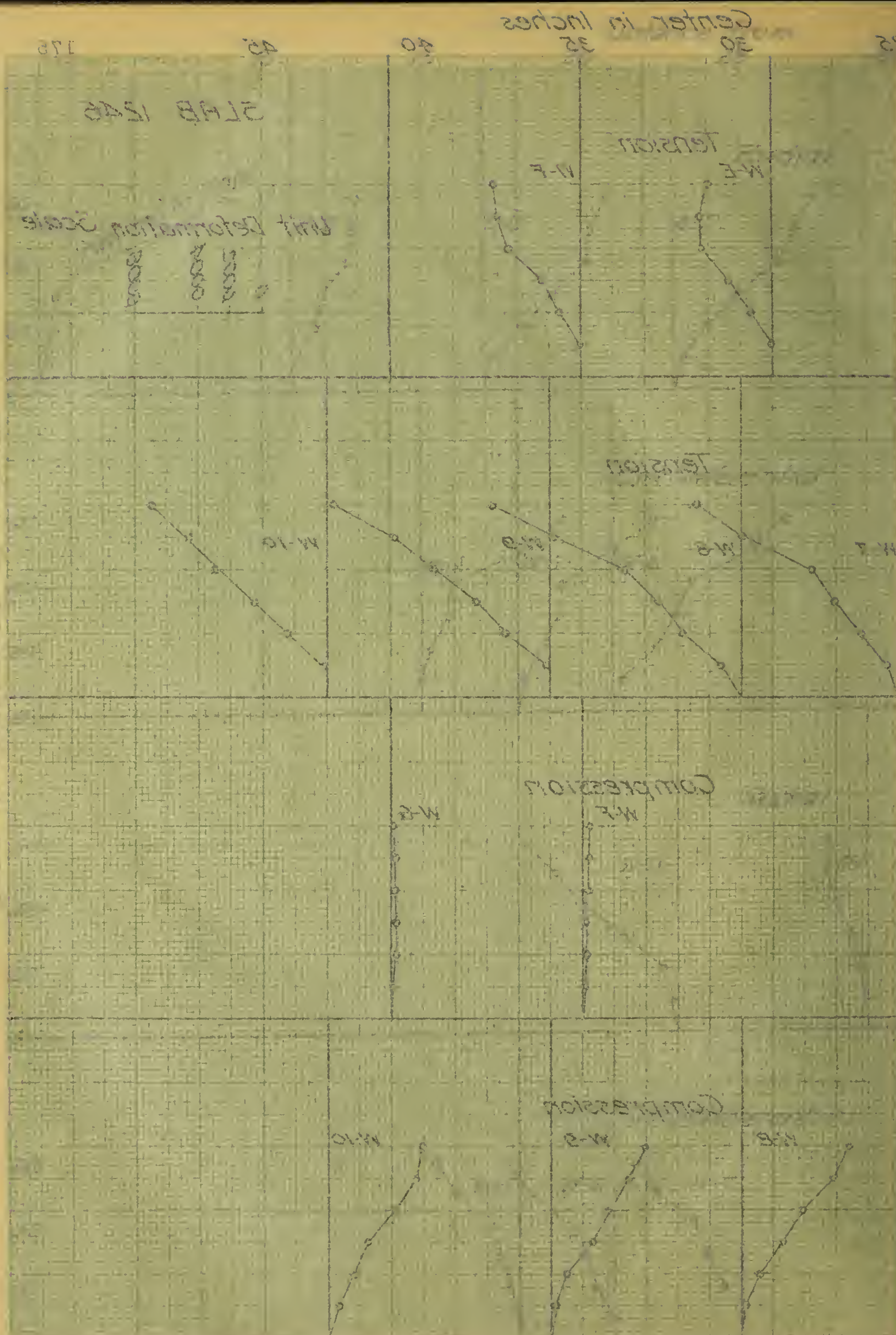


Distance from
10
15
20
25
30
Load in Thousands of Pounds
Radial
W-A
From rod to plate
W-B
W-C
W-D
Circumferential
W-4
W-5
W-6
Radial
W-D
W-E
Circumferential
W-15
W-6
W-7
0
20
40
60

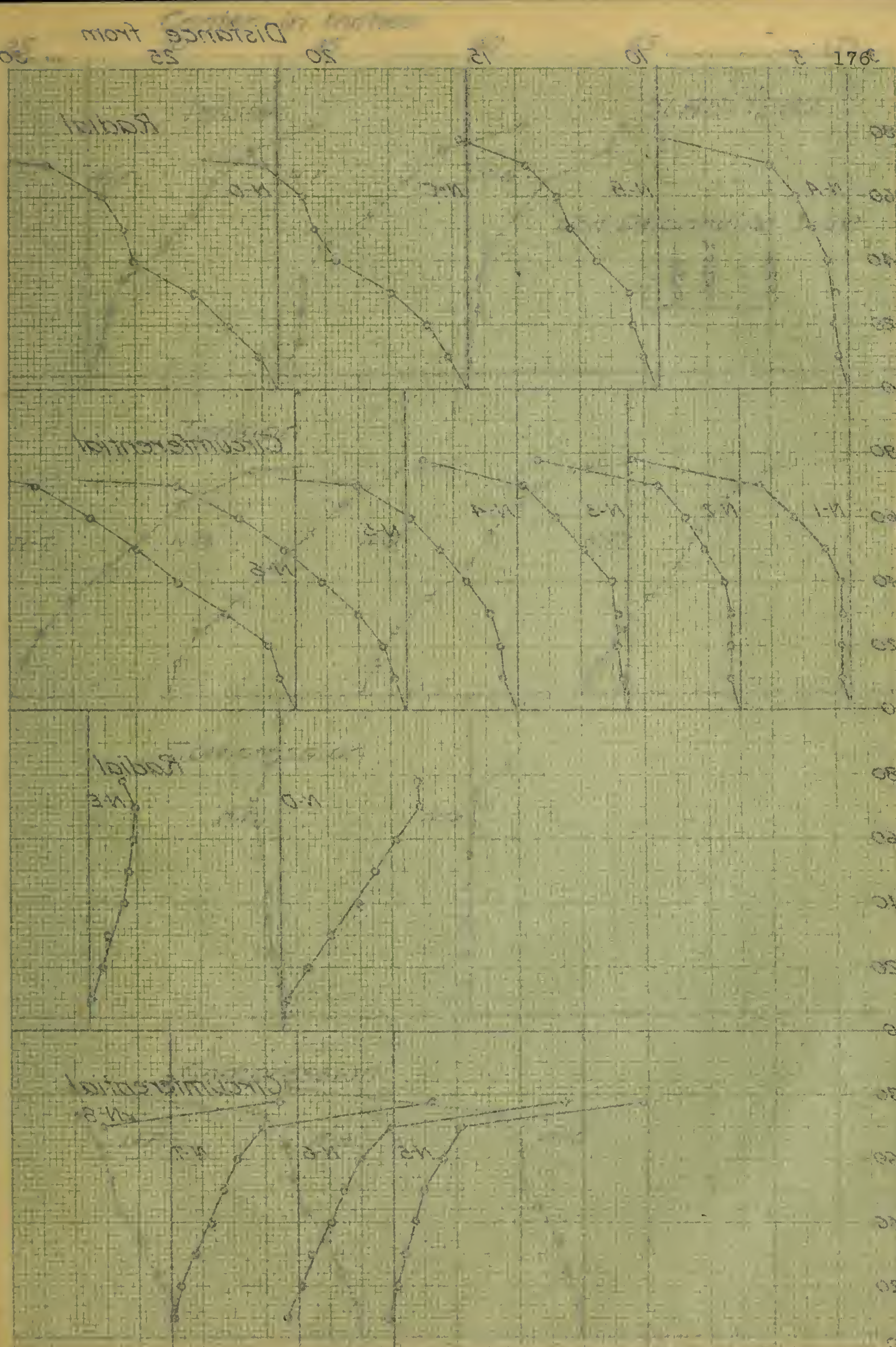


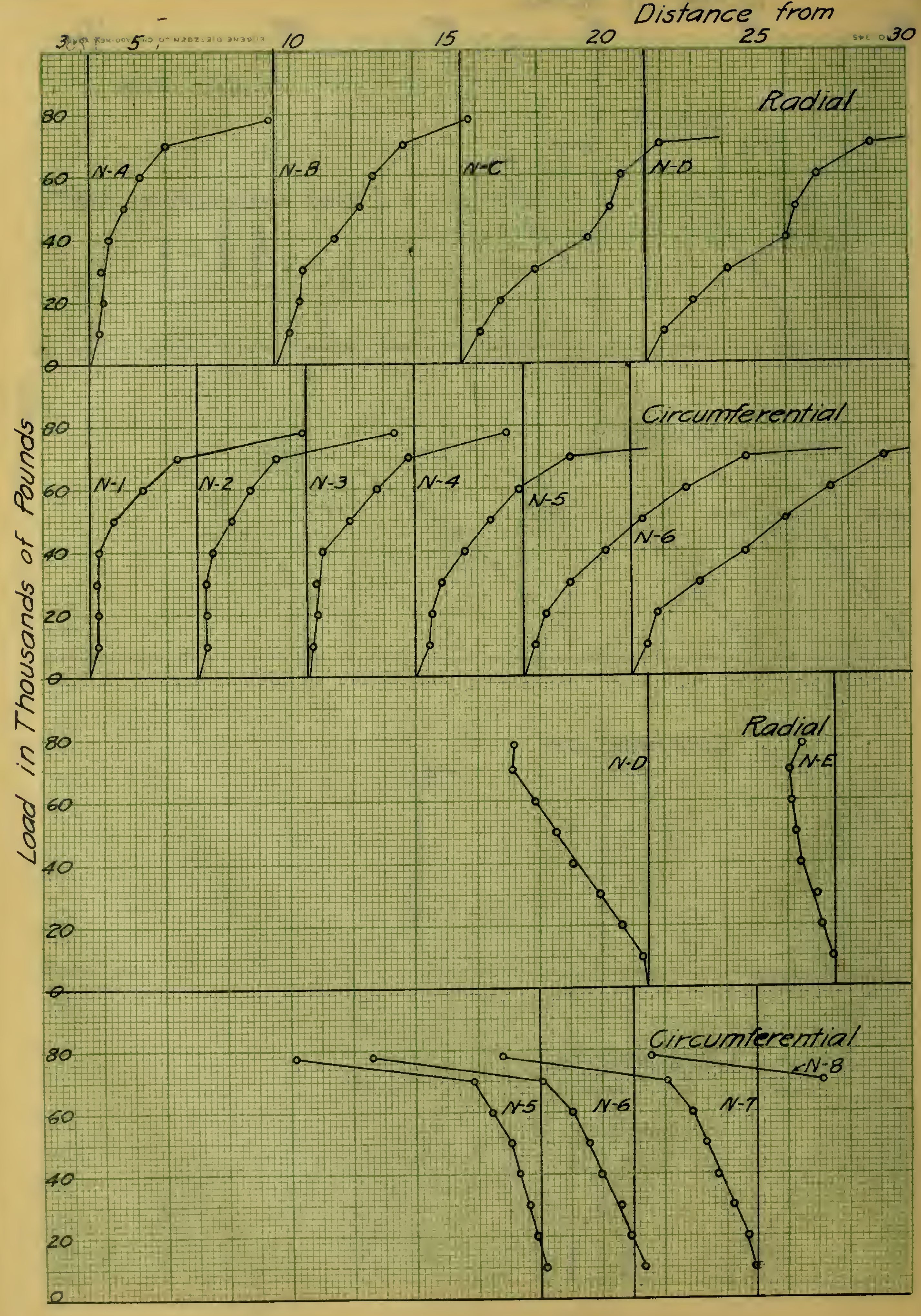
NO 345

EUGENE DIETZGEN CO. CHICAGO-NEW YORK

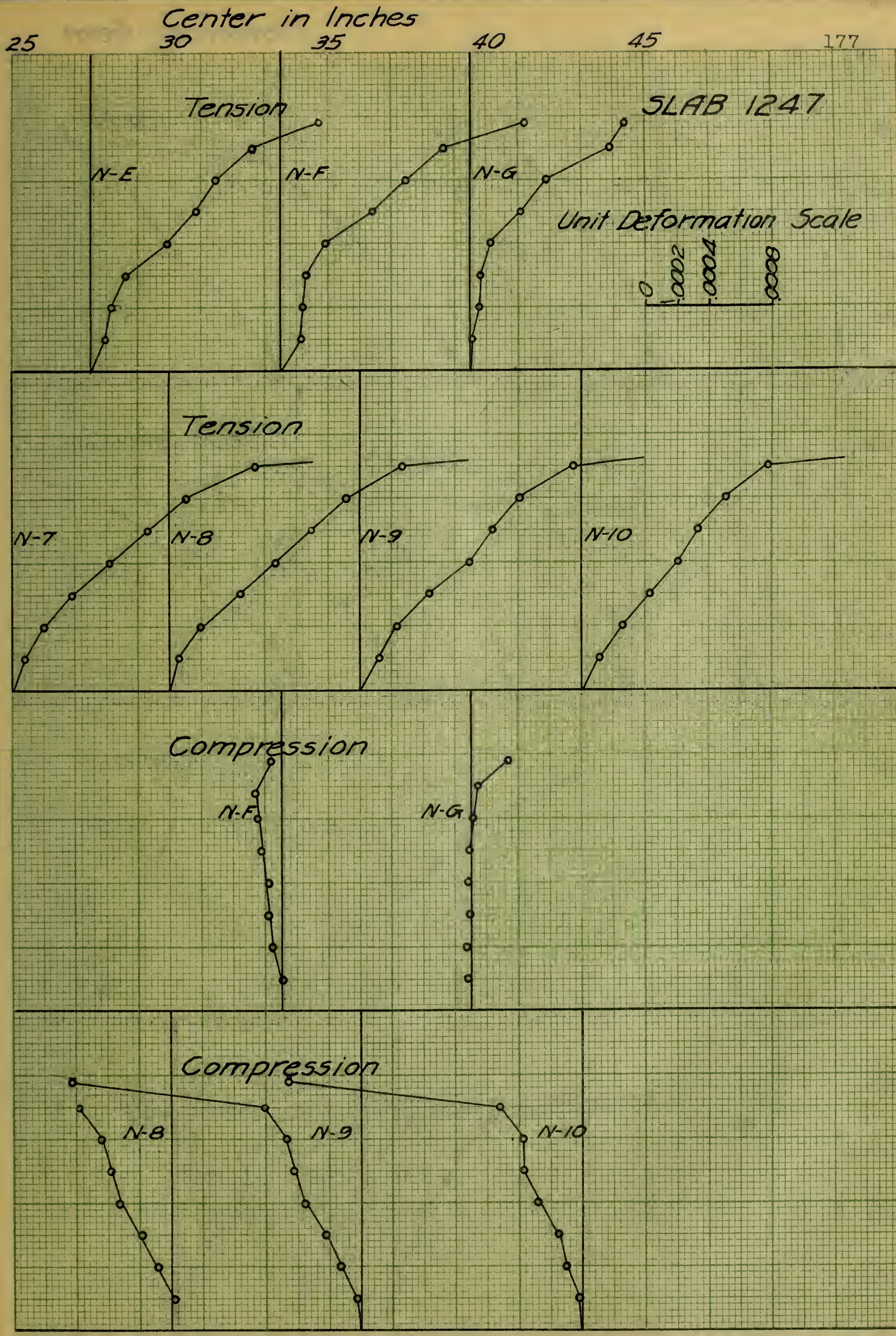


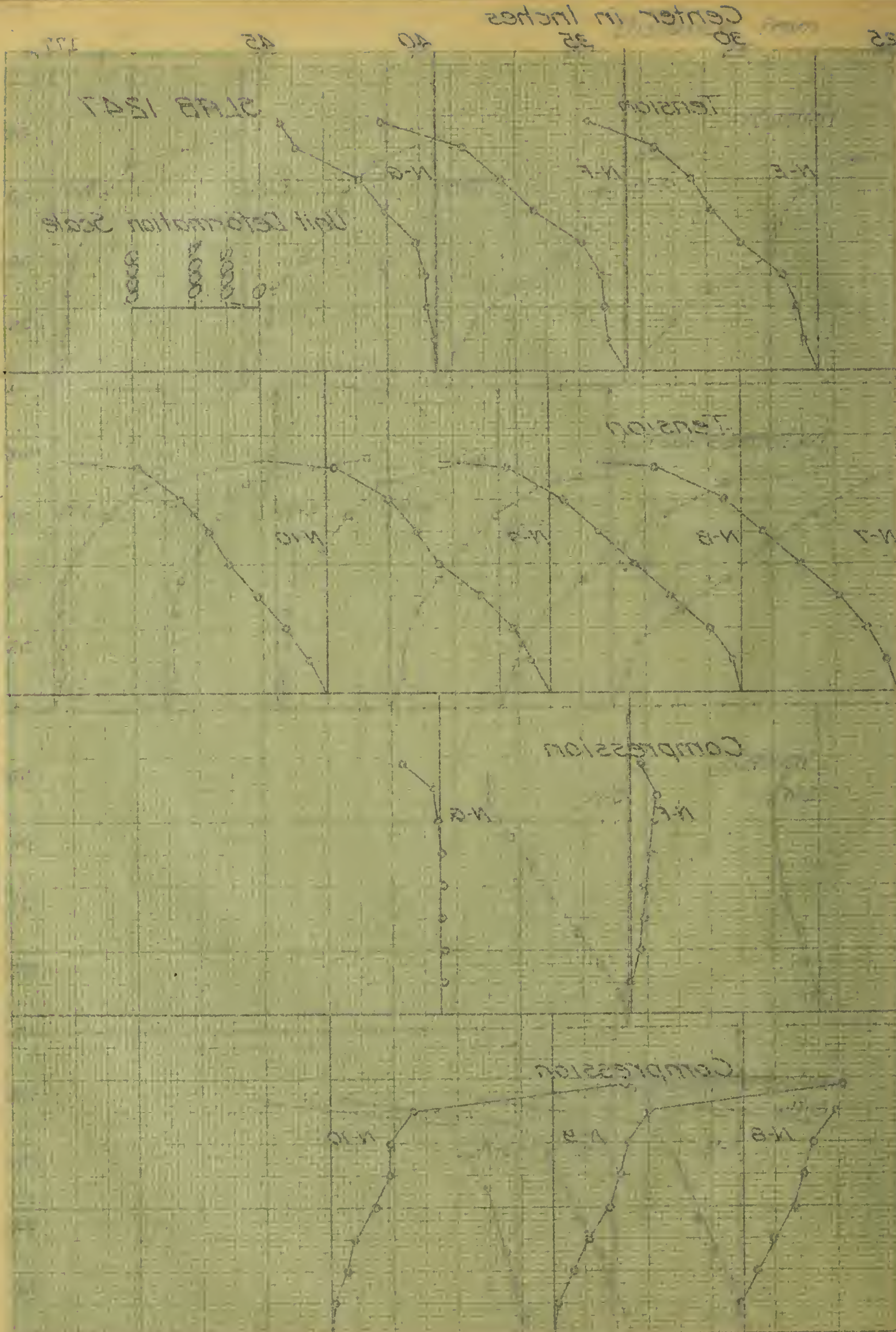
Center in Inches
25
30
35
40
45
SLAB 1245
Unit Deformation Scale
Tension
W-E
W-F
Tension
W-7
W-8
W-9
W-10
Compression
W-5
W-6
Compression
W-8
W-9
W-10


Distance from
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential

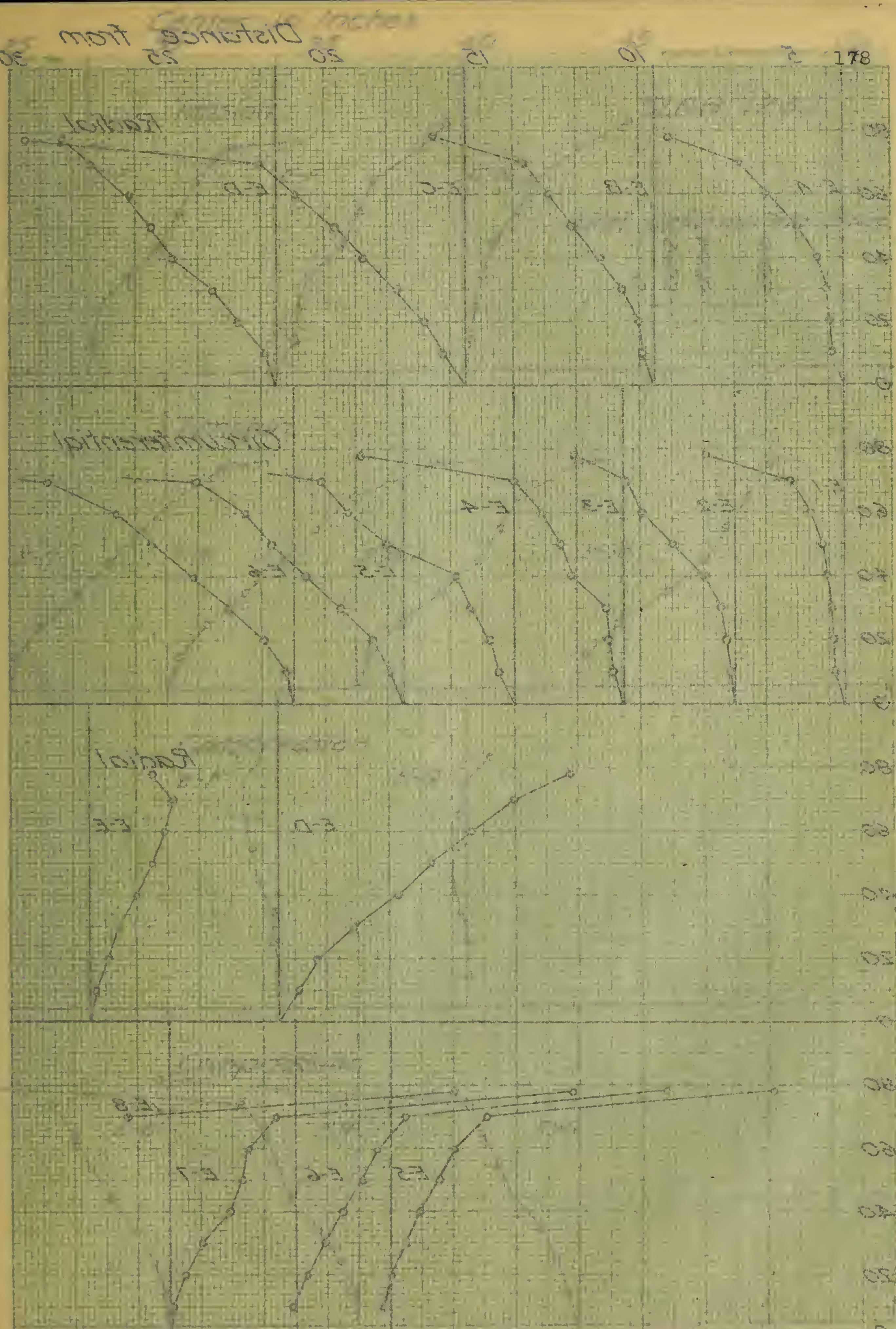


Distance from
3
5
10
15
20
25
30
Radial
N-A
N-B
N-C
N-D
Circumferential
N-1
N-2
N-3
N-4
N-5
N-6
Radial
N-D
N-E
Circumferential
N-5
N-6
N-7
N-8
Load in Thousands of Pounds
80
60
40
20
0

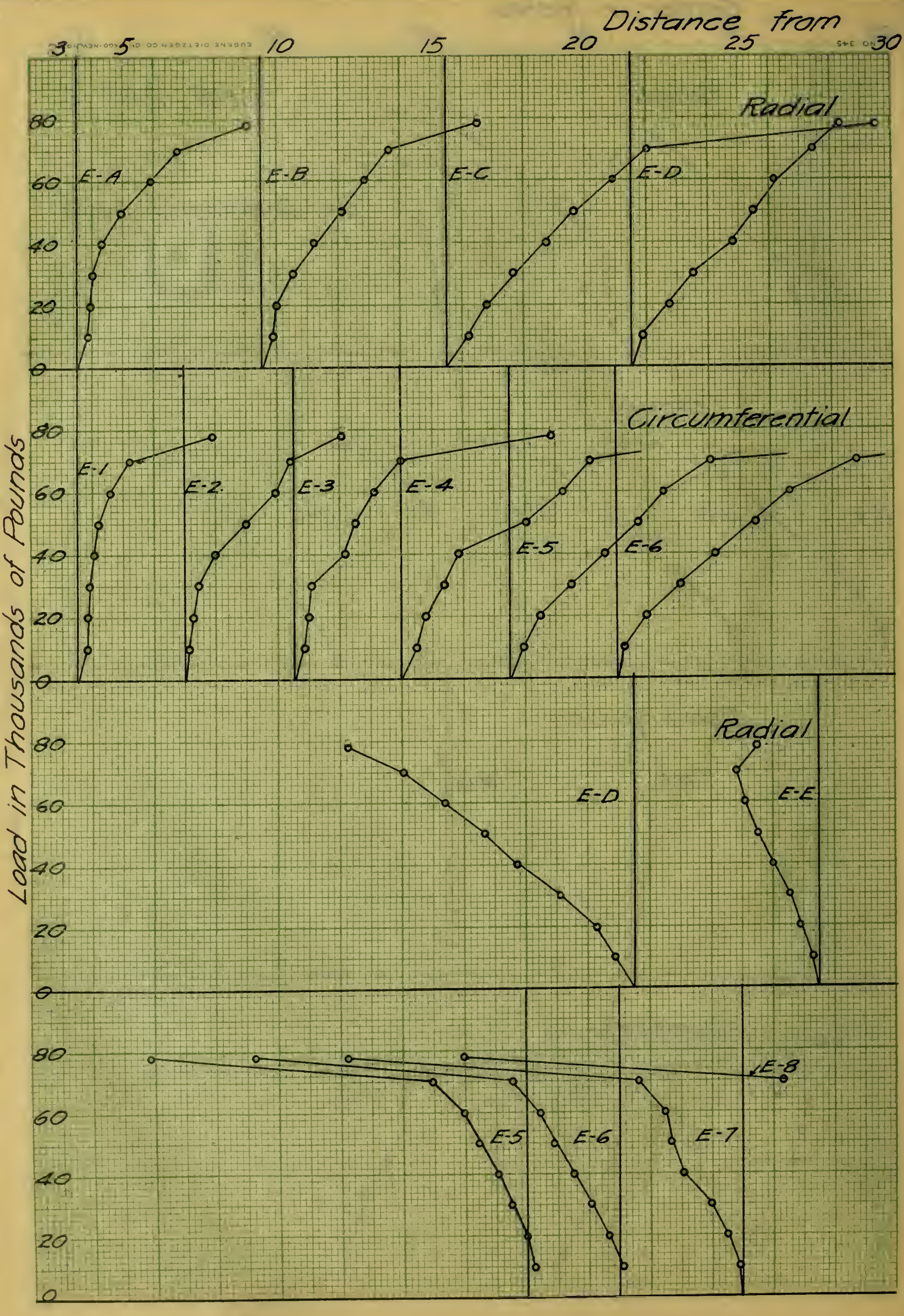

Center in Inches
25
30
35
40
45
SLAB 1247
Tension
N-E
N-F
N-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
N-7
N-8
N-9
N-10
Compression
N-F
N-G
Compression
N-8
N-9
N-10
NO. 345
EUGENE DIETZGEN CO., CHICAGO-NEW YORK.



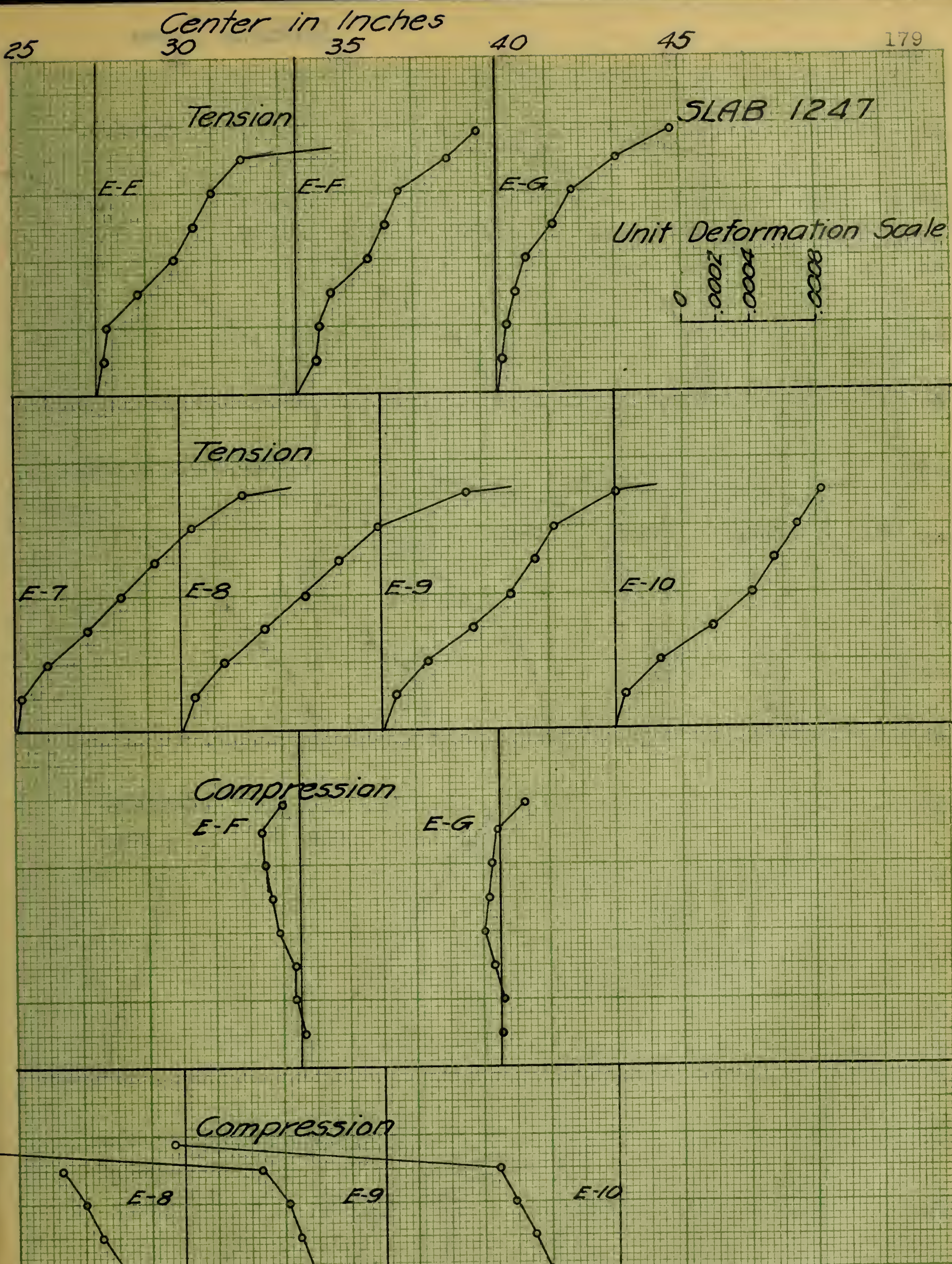
Center in Inches
25
30
35
40
45
SLAB 1247
Tension
N-E
N-F
N-G
Unit Deformation Scale
Tension
N-7
N-8
N-9
N-10
Compression
N-F
N-G
Compression
N-8
N-9
N-10
Load in Thousands of Pounds



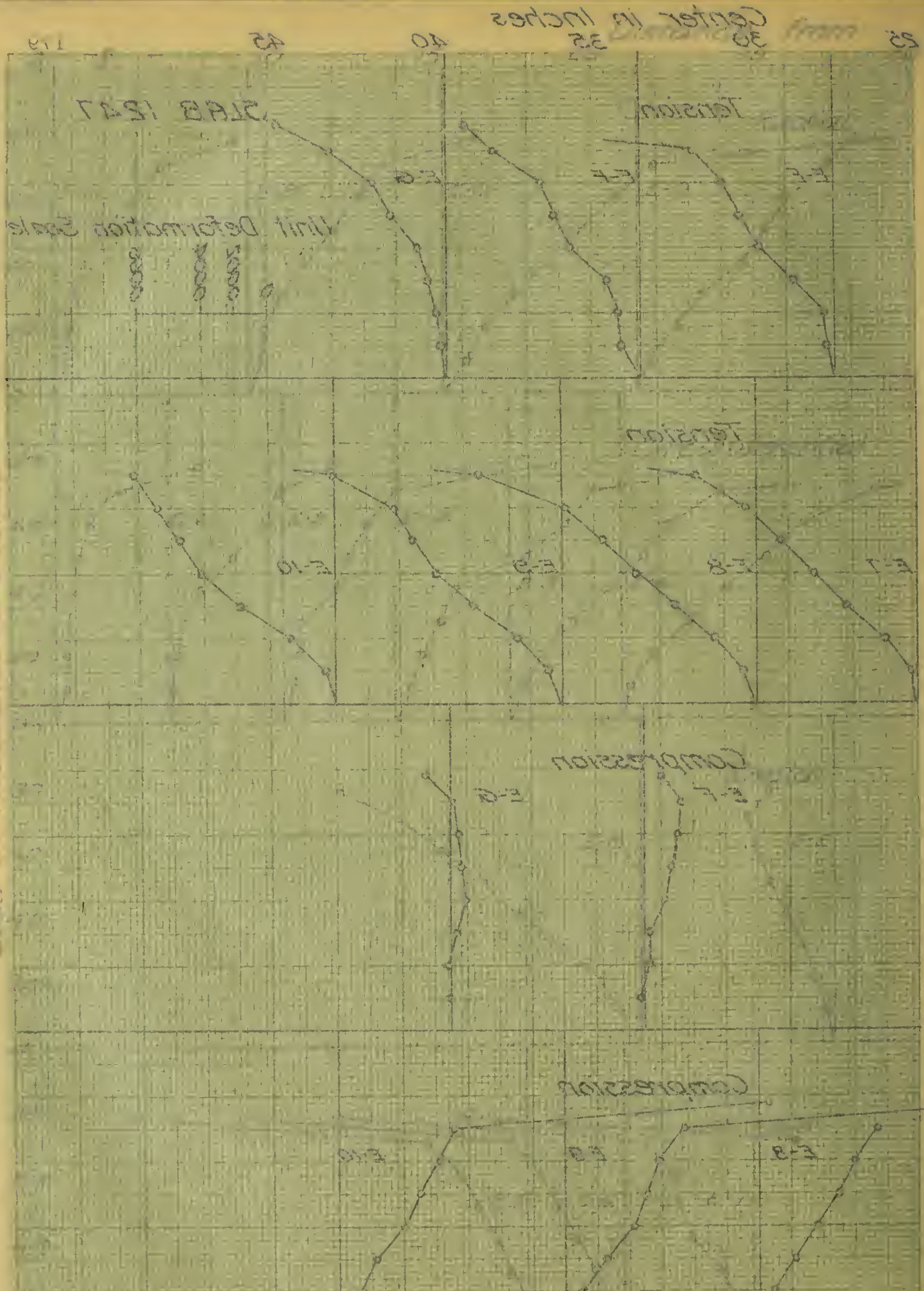
Distance from Center in Inches
Load in Thousands of Pounds
Radial
Circumferential
Radial

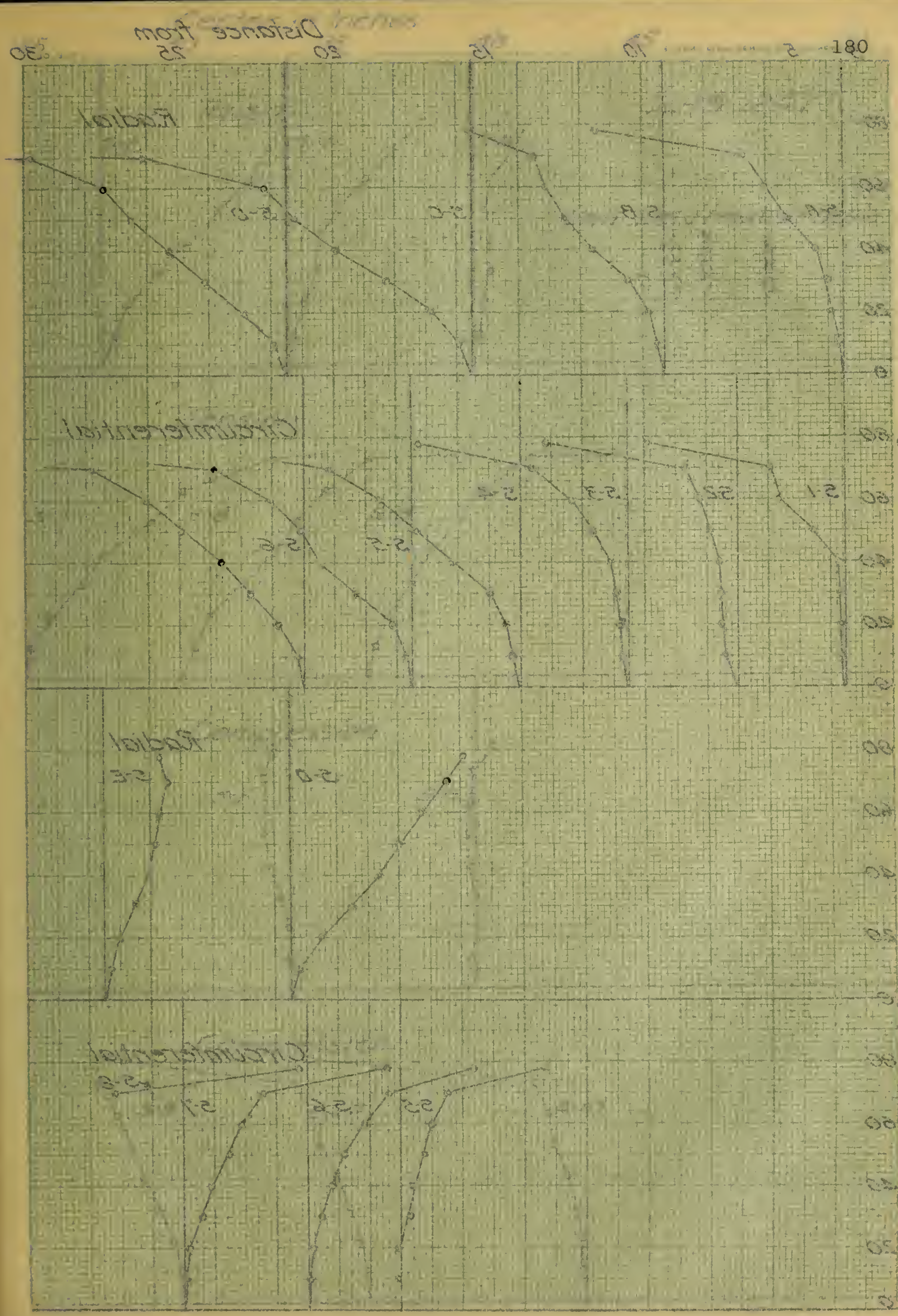


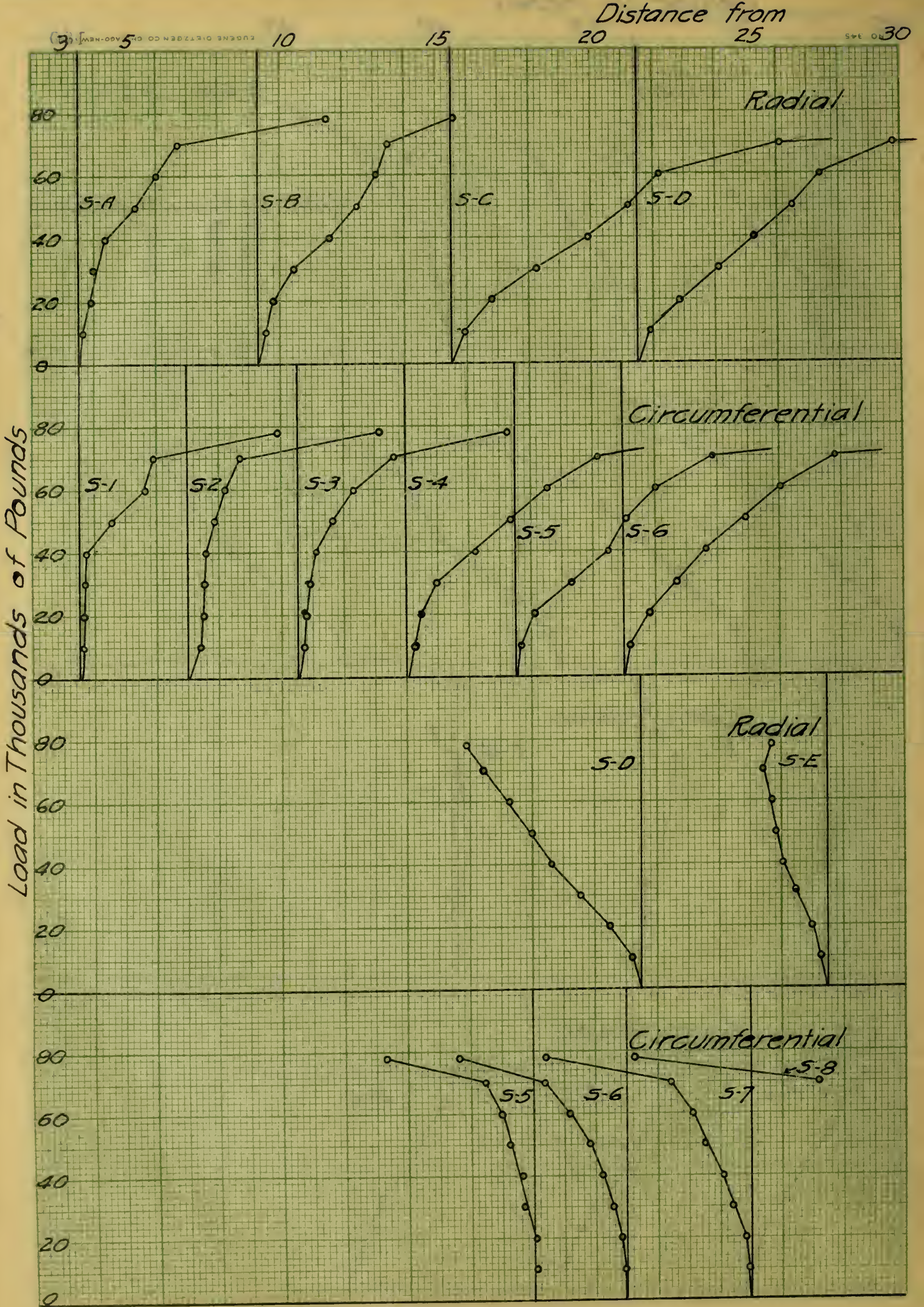
Distance from
3
5
10
15
20
25
30
Radial
E-A
E-B
E-C
E-D
Circumferential
E-1
E-2
E-3
E-4
E-5
E-6
Radial
E-D
E-E
E-5
E-6
E-7
E-8
Load in Thousands of Pounds
0
20
40
60
80
EUGENE DIETZGEN CO. CHICAGO-NEW YORK
NO 345

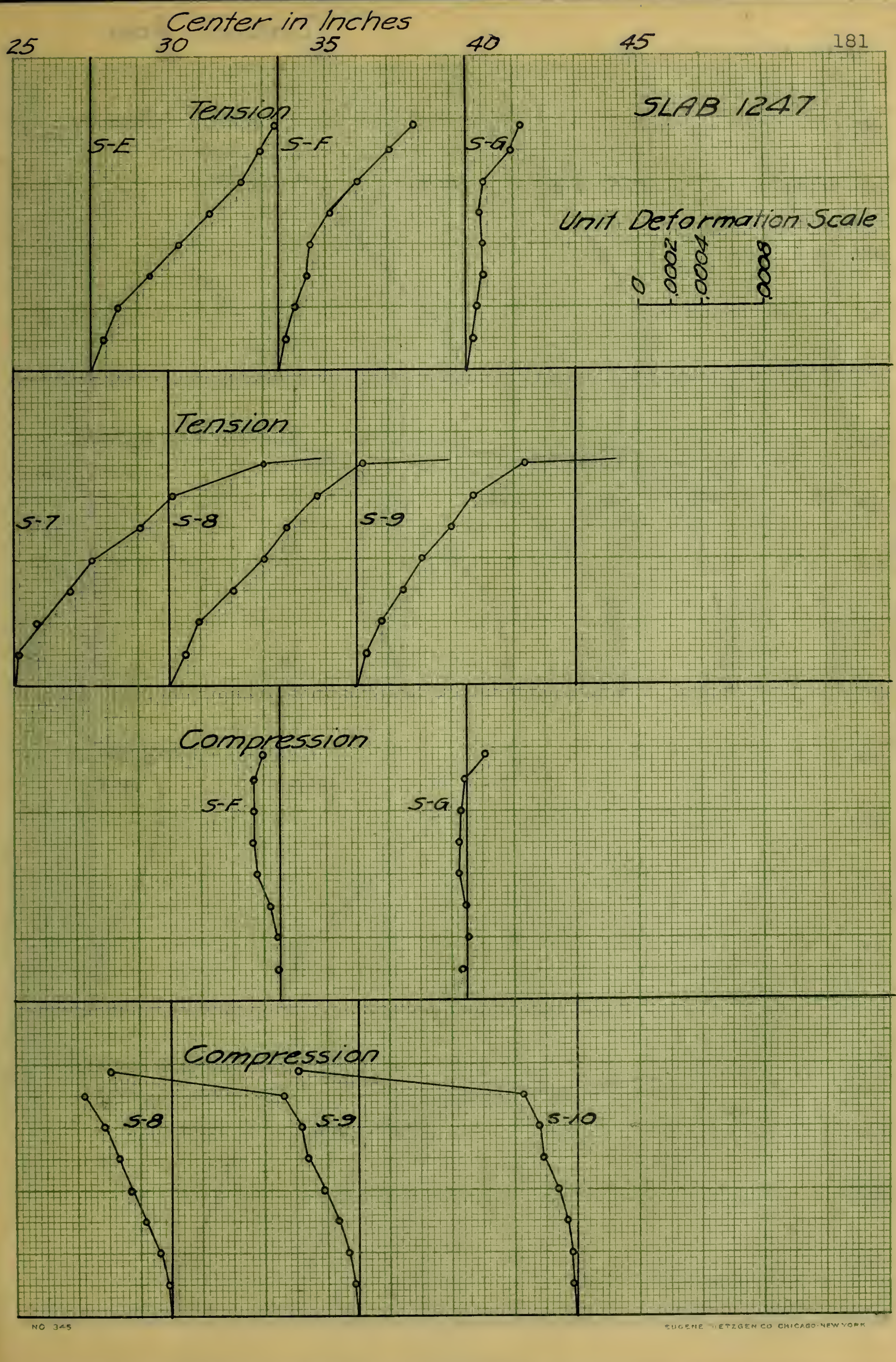


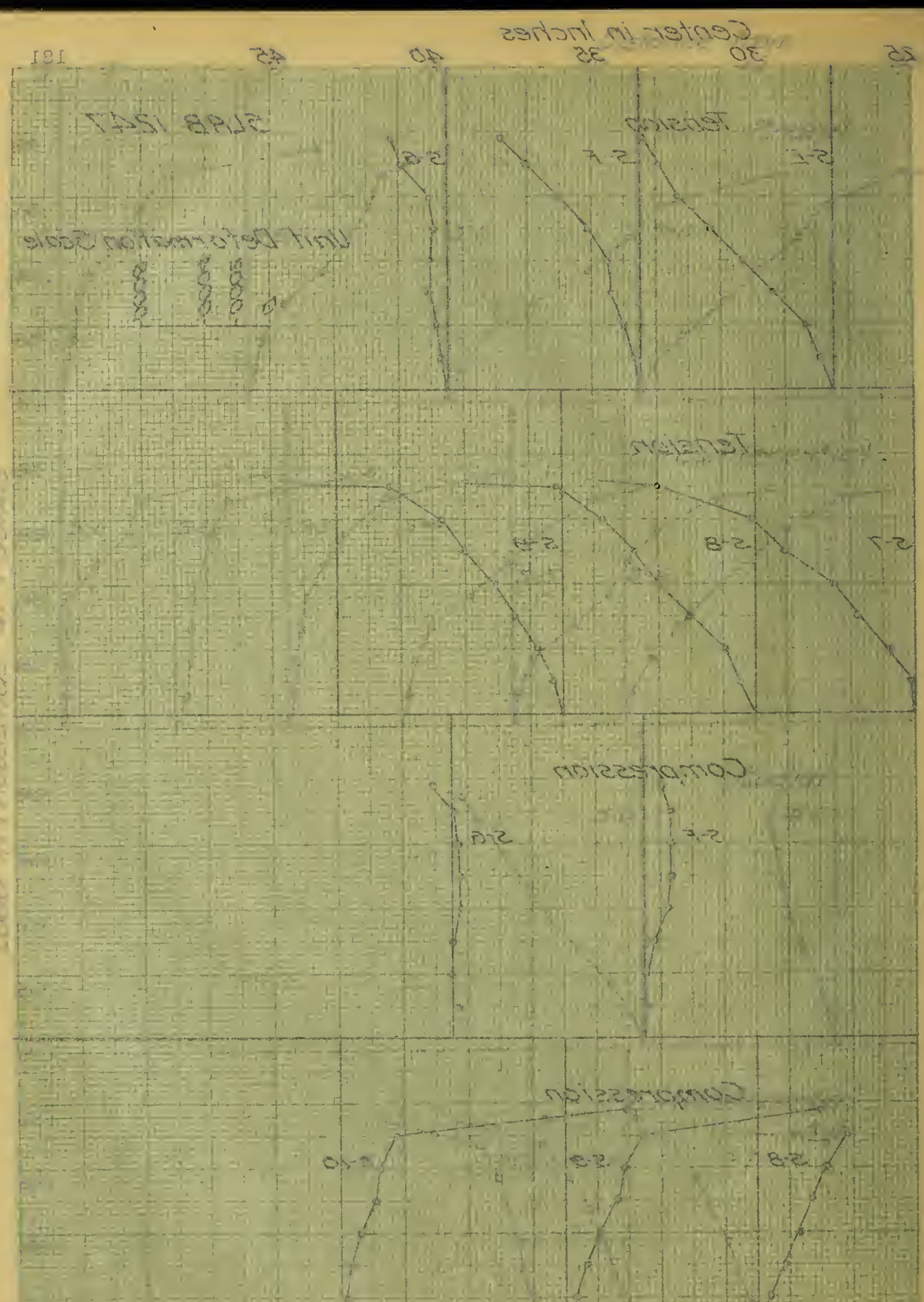
Center in Inches
25
30
35
40
45
SLAB 1247
Tension
E-E
E-F
E-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
E-7
E-8
E-9
E-10
Compression
E-F
E-G
Compression
E-8
E-9
E-10


Center in Inches
25
30
35
40
45
SLAB 1247
Unit Deformation Scale
Tension
E-5
E-F
E-G
E-7
E-8
E-9
E-10
Compression
E-6
E-F

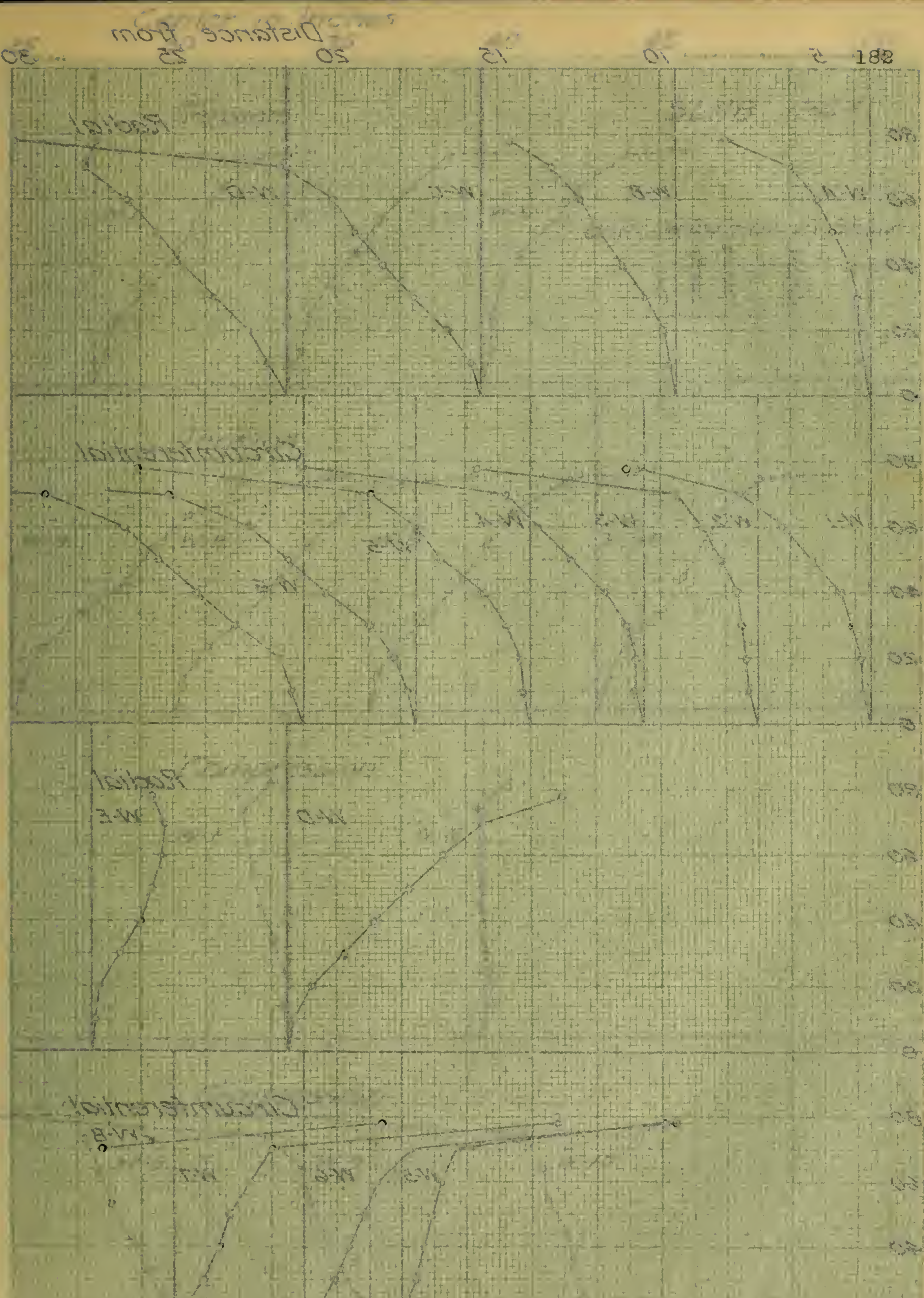

Distance from Center Inches
Load in Thousands of Pounds
Radial
Circumferential
Radial
Circumferential
S-1
S-2
S-3
S-4
S-5
S-6
S-7
S-8
S-A
S-B
S-C
S-D
S-E

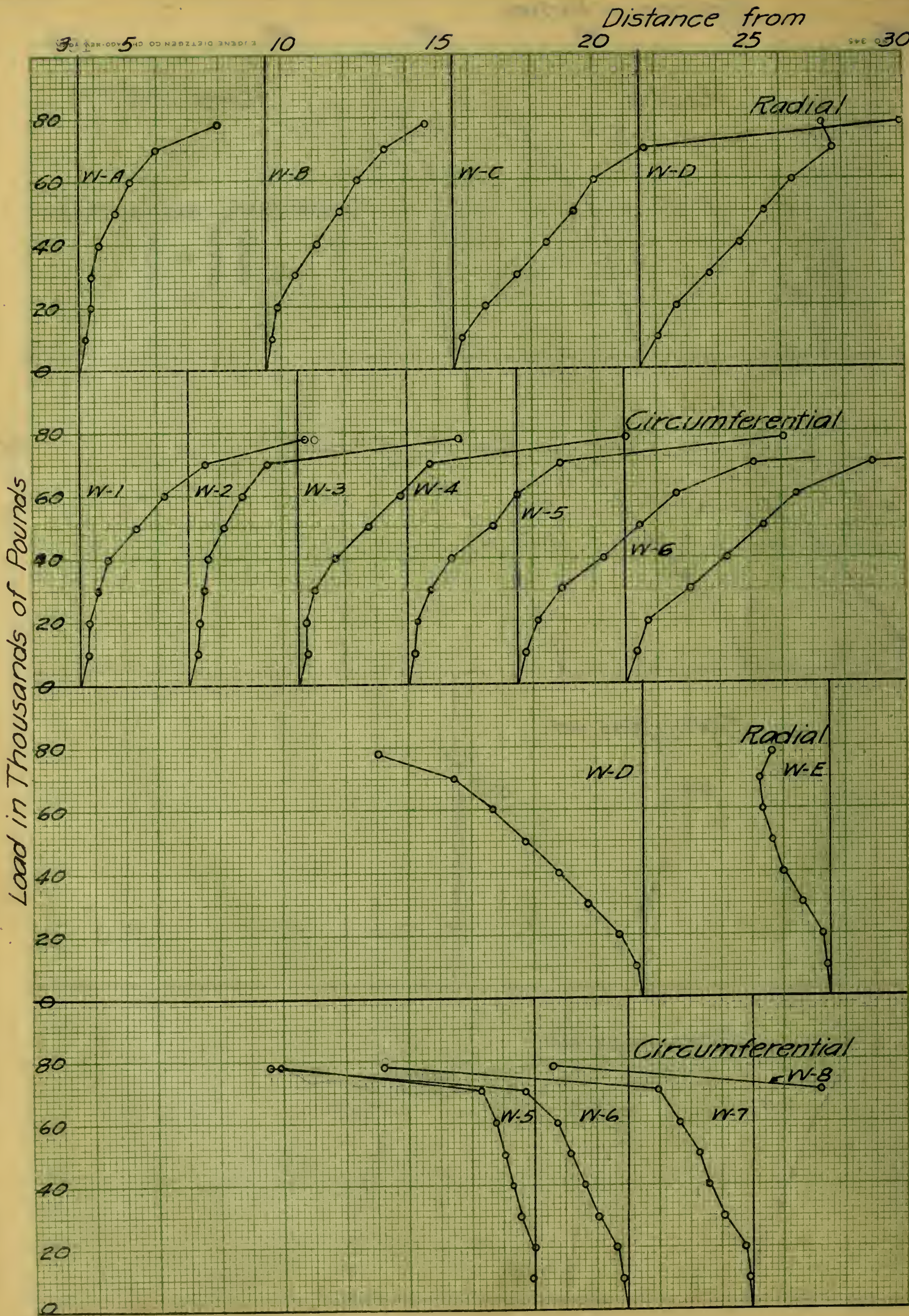

Distance from
5
10
15
20
25
30
Load in Thousands of Pounds
Radial
S-A
S-B
S-C
S-D
Circumferential
S-1
S-2
S-3
S-4
S-5
S-6
Radial
S-D
S-E
Circumferential
S-5
S-6
S-7
S-8
0
20
40
60
80


Center in Inches
25
30
35
40
45
SLAB 1247
Tension
S-E
S-F
S-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
S-7
S-8
S-9
Compression
S-F
S-G
Compression
S-8
S-9
S-10
NO 345
EUGENE DIETZGEN CO. CHICAGO-NEW YORK

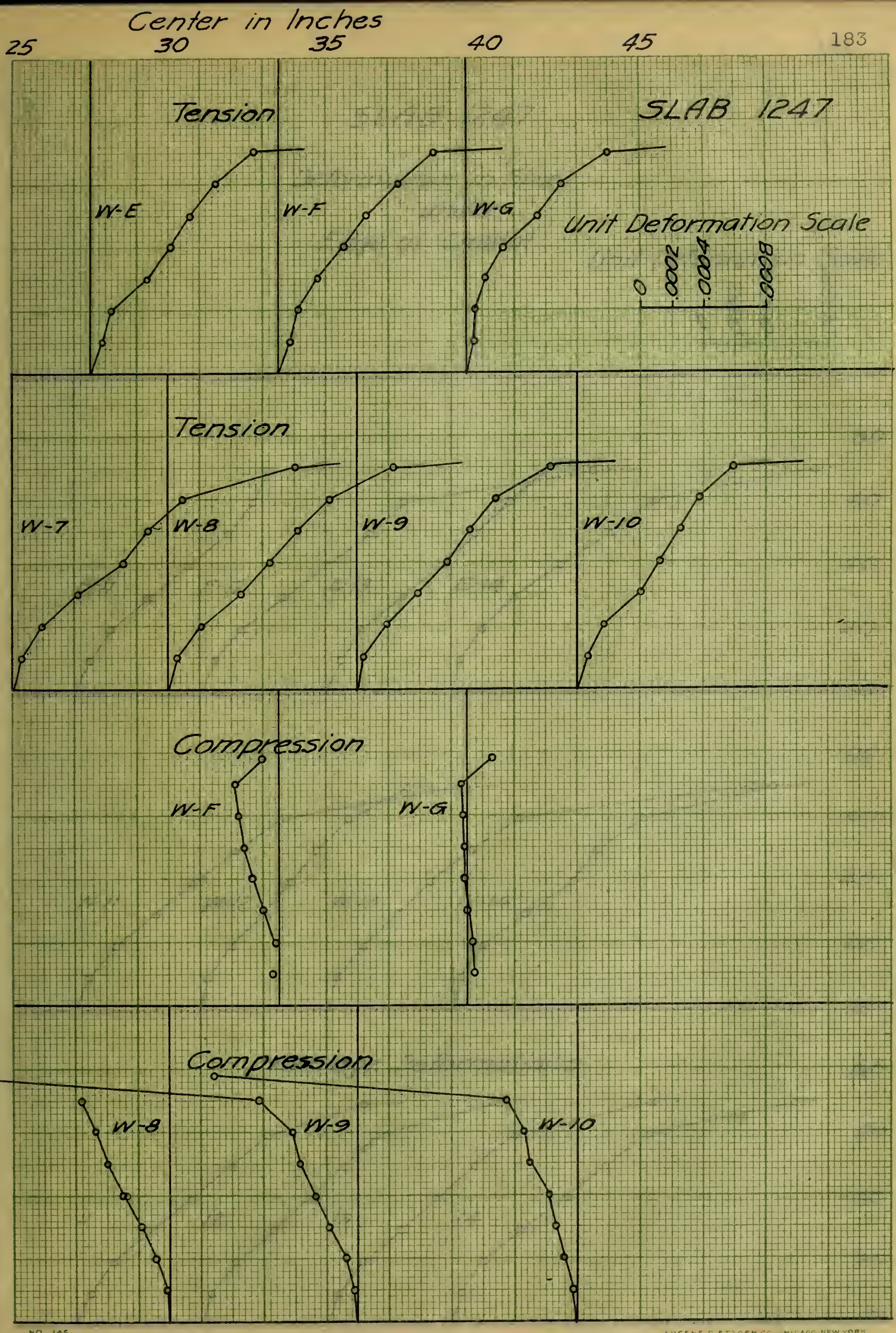


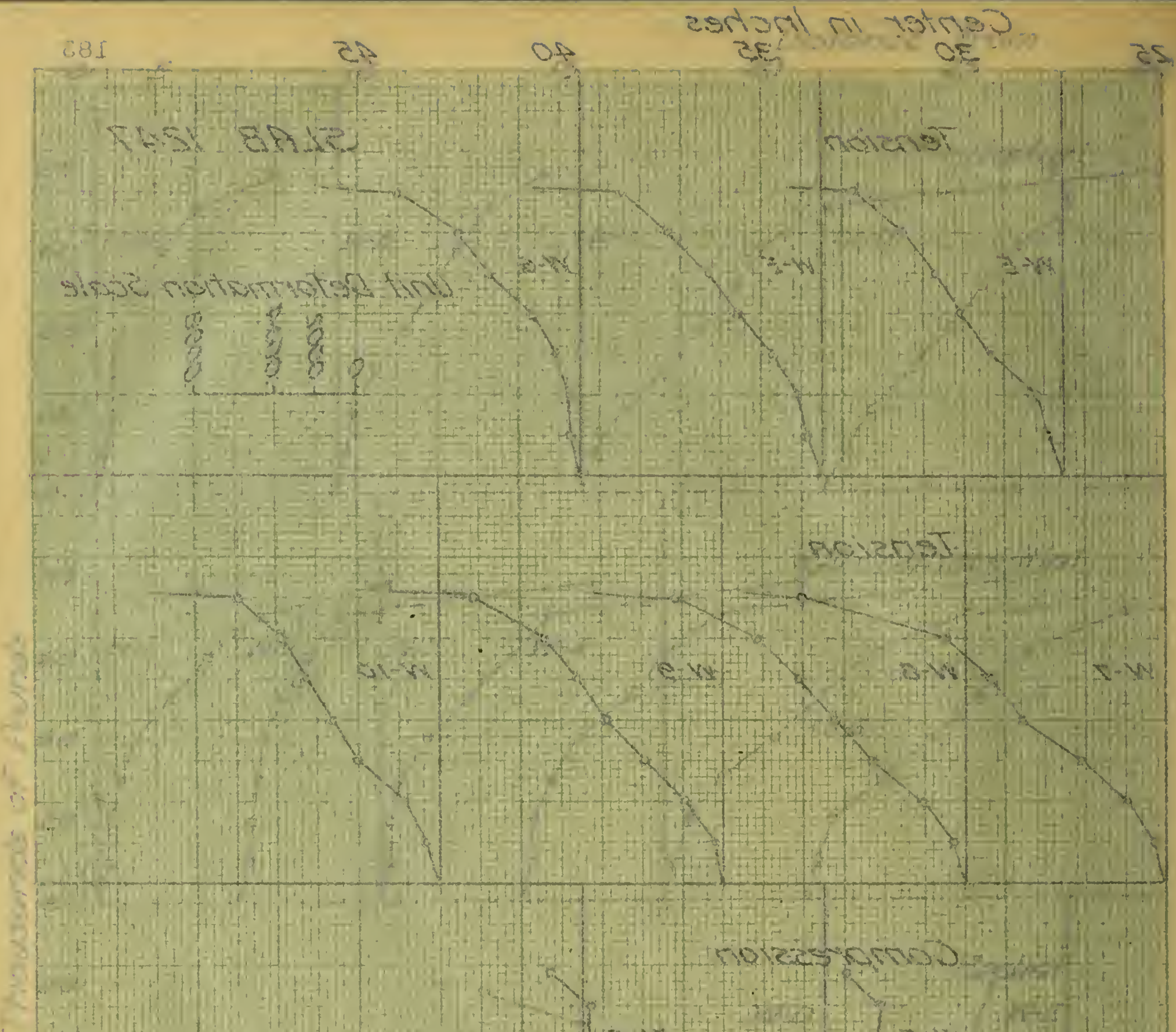
Center in Inches
25
30
35
40
45
SLAB 1247
Tension
Unit Deformation Scale
Compression
Load in Thousands of Pounds

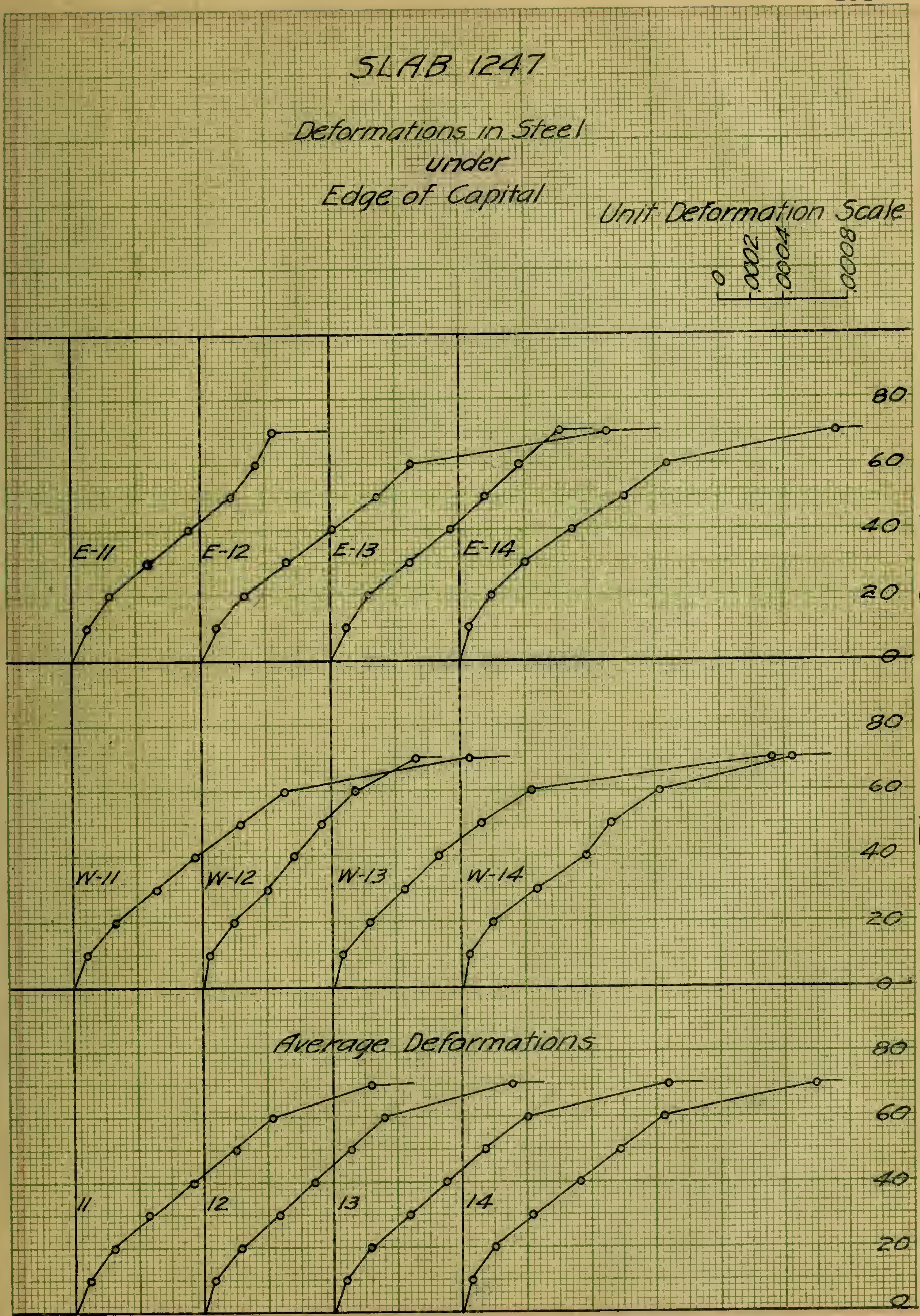


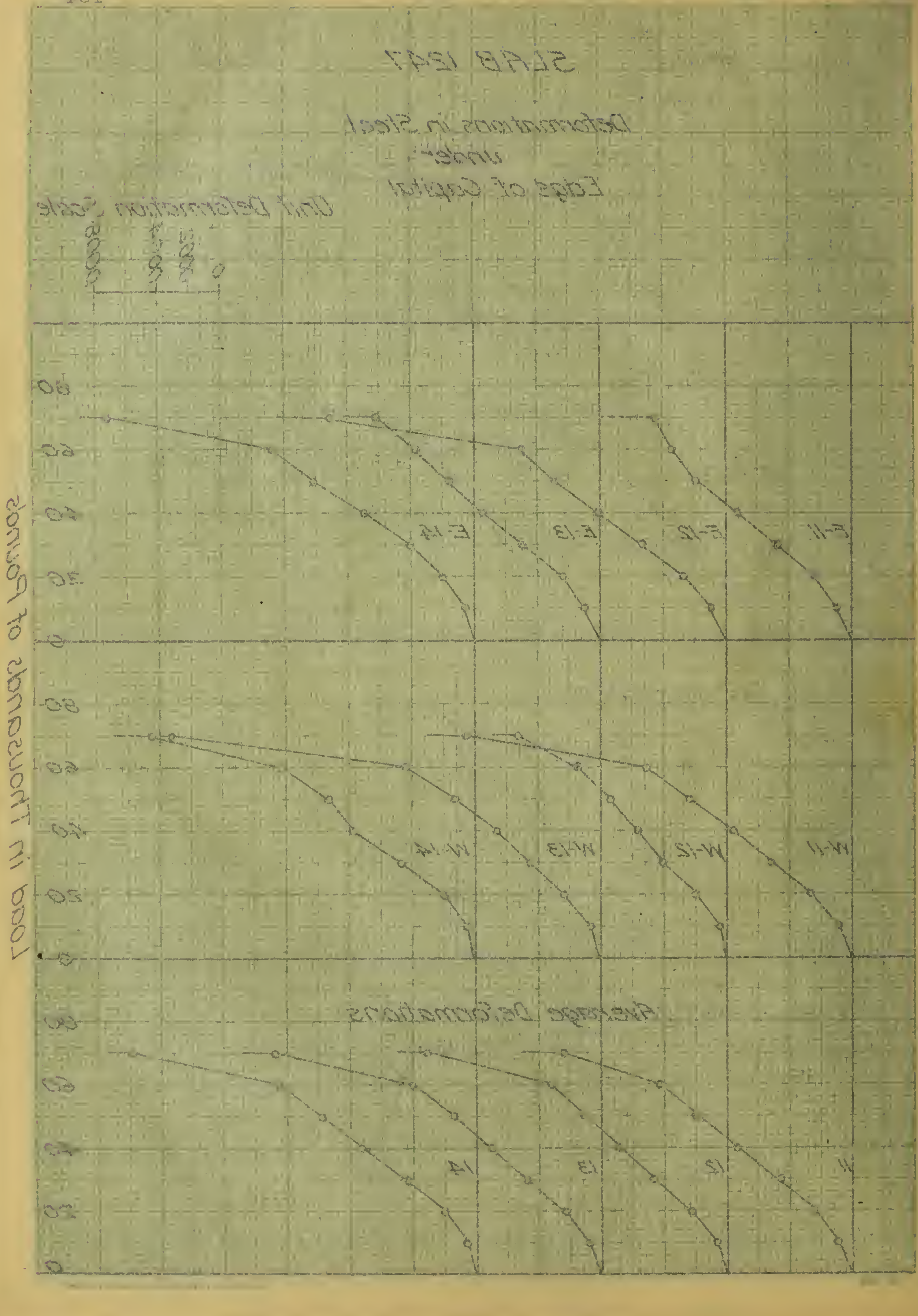


Distance from
5
10
15
20
25
30
Load in Thousands of Pounds
0
20
40
60
80
Radial
W-A
W-B
W-C
W-D
Circumferential
W-1
W-2
W-3
W-4
W-5
W-6
Radial
W-D
W-E
Circumferential
W-5
W-6
W-7
W-8


Center in Inches
25
30
35
40
45
SLAB 1247
Tension
W-E
W-F
W-G
Unit Deformation Scale
0
.0002
.0004
.0008
Tension
W-7
W-8
W-9
W-10
Compression
W-F
W-G
Compression
W-8
W-9
W-10
NO 345
EUGENE DIETZGEN CO. CHICAGO NEW YORK


Center in Inches
25
30
35
40
45
SLAB 12-47
Tension
Unit Deformation Scale
Tension
Compression
Compression


SLAB 1247
Deformations in Steel
under
Edge of Capital
Unit Deformation Scale
0
.0002
.0004
.0008
E-11
E-12
E-13
E-14
W-11
W-12
W-13
W-14
Average Deformations
11
12
13
14
80
60
40
20
0
Load in Thousands of Pounds


SLAB 1247
Deformations in Steel
under
Edge of Capital
Unit Deformation Scale
Load in Thousands of Pounds
E-11
E-12
E-13
E-14
W-11
W-12
W-13
W-14
Average Deformations
11
12
13
14

VI. LOG OF TESTS

SLAB 1241. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line						
	A	B	C	D	E	F	G
			10 000 lb. Load				
N		1.2	3.6	2.8	1.7	1.5	2.8
E	2.0	1.6	2.4	2.2	.7	3.2	4.0
S		.6	2.9	1.4	1.0	3.5	1.1
W	.5c	1.0	3.5	..8	.6	1.9	.7
Av.	.7	1.1	3.1	1.8	1.0	2.5	2.1
			20 000 lb. Load				
N		.7	6.6	8.2	6.5	4.7	6.5
E	1.5	2.0	9.0	10.1	1o.3	7.5	1.2
S		1.4c	4.3	5.0	5.8	5.1	4.4
W	3.4c	2.4	12.1	7.8	6.0	7.2	8.9
Av.	1.0c	.9	8.0	7.8	7.1	6.1	5.2
			30 000 lb. Load				
N		6.8	21.4	23.4	20.4	19.1	20.6
E	5.5	14.7	27.0	30.7	31.2	24.2	11.1
S		11.8	20.9	25.2	22.0	21.0	19.1
W	1.3	1o.8	25.2	20.4	28.6	31.6	26.4
Av.	3.4	11.0	23.6	24.9	25.5	24.0	10.3
			35 000 lb. Load				
N		8.6	18.4	20.4	18.5	18.6	20.6
E	9.0	16.5	23.9	23.0	26.3	21.4	13.6
S		11.5	16.9	20.4	18.9	18.3	15.9
W	3.7	11.5	22.5	25.4	22.0	24.4	23.5
Av.	6.3	12.0	20.4	22.3	21.4	20.7	18.3

c,- compression; all others are tension.

SLAB 1241. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line 4	5	6	7	8	9	10
			10 000 lb. Load				
N	2.9	1.2	1.3	.2	.1	2.9	4.1
E		.5	o	1.1	.1c	2.7	4.6
S	.8	2.2	2.4	2.2	1.9	1.6	2.2
W	.6	2.1	2.7	3.3	2.5	2.9	
Av.	1.4	1.5	1.6	1.7	1.1	2.5	3.6
			20 000 lb. Load				
N	1.9	3.6	14.4	11.9	11.8	18.1	17.1
E		6.5	11.9	12.9	11.9	16.1	16.1
S	1.3	4.5	4.3	12.0	13.8	15.5	15.9
W	2.5	10.0	12.2	13.9	14.6	17.4	
Av.	1.9	6.1	10.7	12.7	13.0	16.8	16.4
			30 000 lb. Load				
N	2.3	3.9	32.4	29.1	28.4	42.7	39.2
E		8.2	25.2	33.3	31.9	34.8	34.3
S	.3	4.7	13.0	38.3	44.6	41.7	46.4
W	.1c	13.2	13.6	29.3	45.7	43.4	
Av.	.8	7.5	21.0	32.5	37.6	40.6	40.0
			35 000 lb. Load				
N	4.0	2.0	27.4	27.5	36.8	41.3	35.6
E		7.1	19.7	31.3	30.5	29.9	29.4
S	2.9	4.2	10.6	33.5	38.6	36.9	40.8
W	6.9c	9.4	9.5	24.7	35.8	34.7	
Av.	0	5.7	14.8	29.2	35.4	35.7	35.3

c,- compression; all others are tension.

SLAB 1241. CONCRETE DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line									
	D	E	F	G	5	6	7	8	9	10
				10 000 lb. Load						
N	2.4	2.1	.6	.9	.1	2.0	.9	2.1	2.9	2.8
E	2.4	.5		.3	1.5	1.8	.2	.4	1.0	3.1
S	2.4	.2	2.1	.6t	.8	.8	.1	1.1	1.1	1.0
W	2.8	.7	1.5	.1	.7	2.1	2.4	1.7	2.2	2.4
Av.	2.5	.9	1.4	.2	.8	1.7	.9	1.3	1.8	2.3
				20 000 lb. Load						
N	8.2	4.8	1.2	.2t	6.7	9.2	9.6	11.2	10.0	9.0
E	7.4	.7		.7t	3.0	6.4	8.4	7.6	8.0	9.8
S	9.3	.1	2.2	1.4t	.9	5.3	12.0	8.9	7.1	5.5
W	8.8	1.1	1.0	.3t	3.6	8.7	9.8	9.1	11.5	7.8
Av.	8.4	1.7	1.5	.6t	3.5	7.4	9.9	9.2	9.1	8.0
				30 000 lb. Load						
N	17.6	10.7	1.6	.7t	9.7	13.1	14.6	18.2	19.5	19.5
E	19.0	3.6		.5t	4.3	7.4	14.3	15.0	16.6	19.9
S	28.0	5.4	4.4	.8t	1.5	9.9	16.4	19.3	17.5	15.5
W	32.1	6.9	3.3	.1t	9.8	14.6	21.4	19.7	21.8	16.8
Av.	24.2	6.6	3.1	.5t	6.3	11.2	16.7	18.0	18.8	17.9
				35 000 lb. Load						
N	17.6	10.7	2.9	.8	8.8	11.5	14.4	18.8	19.0	19.0
E	19.6	4.9		1.2t	5.0	9.0	13.1	13.1	13.5	17.6
S	25.5	5.0	5.1	.8t	1.4	8.7	14.4	17.0	16.2	13.3
W	29.5	6.4	3.8	.2	12.0	12.1	18.8	16.7	19.1	13.4
Av.	23.0	6.7	3.9	.2t	6.8	10.3	15.2	16.4	16.9	15.8

t,- tension; all others are compression.

SLAB 1242. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line A	B	C	D	E	F	G
			10 000 lb. Load.				
N			1.5	1.4		3.0	2.3
E	1.8	2.4	4.2	1.3	2.0	3.5	.3
S	.5	1.0	1.4	1.4	.6	1.2	.6c
W	.7c	.5c	1.8	2.0	1.8	.4	1.0
Av.	.5	1.0	2.2	1.5	1.5	2.0	.7
			15 000 lb. Load				
N			7.3	3.8		4.4	2.6
E	1.2	2.5	6.0	3.9	2.0	1.7	.4
S	.7	.2	3.7	3.0	1.1	1.6	.1
W	.7	.5	1.5	3.7	1.4	.6c	1.4
Av.	.8	1.0	4.6	3.6	1.5	1.8	1.1
			20 000 lb. Load				
N			10.3	9.5		2.1	2.3
E	.3	1.4	13.4	13.7	6.2	3.5	.7
S	.7	2.0c	13.0	10.5	1.9	2.2	.3c
W	1.2c	.7c	7.0	10.2	4.8	.1	.9
Av.	.1c	.4c	10.9	11.0	4.3	2.0	.9
			25 000 lb. Load				
N			29.0	30.1		12.6	7.7
E	.6	4.6	30.1	39.7	33.4	18.3	1.2
S	.4	5.2	27.6	54.8	15.6	10.0	3.2
W	.3c	3.3	20.4	15.2	19.2	11.3	7.5
Av.	.2	4.4	26.8	34.9	22.7	13.0	4.9
			30 000 lb. Load				
N			28.6	48.8		24.4	18.1
E	1.9c	7.9	31.6	105.8	55.7	26.9	6.0
S	.4	8.6	33.5	121.9	21.6	15.9	11.5
W	1.0c	5.6	27.2	37.4	31.0	22.7	16.1
Av.	.8c	7.4	30.2	78.5	36.1	22.5	12.9

c,- compression; all others are tension.

SLAB 1242. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line 4	5	6	7	8	9	10
			10 000 lb. Load				
N	.8	3.3	1.5	3.1	1.1	2.1	1.0
E	.8	.9	1.1	1.9	3.0	1.9	2.1
S	.6	1.4	.9	.5	1.7	1.8	1.8
W	1.9	1.0	1.7	1.7	1.5	1.3	.9
Av.	1.0	1.6	1.3	1.8	1.8	1.8	1.4
			15 000 lb. Load				
N	2.0	3.7	2.1	4.6	1.1	2.9	1.8
E	1.1	2.6	2.4	3.0	2.7	2.8	4.0
S	.4	2.3	2.4	1.1	2.7	3.5	2.4
W	1.6	.7	1.7	1.9	2.8	2.8	2.8
Av.	1.3	2.3	2,1	2.6	2.3	3.0	2.7
			20 000 lb. Load				
N	1.1c	2.9	4.4	5.3	5.8	8.7	10.8
E	1.7	7.2	8.4	9.9	14.1	16.7	15.5
S	.3	.5	7.1	7.8	11.7	15.4	17.2
W	2.3	2.0	4.9	8.6	10.6	12.6	13.7
Av.	.8	4.6	6.2	7.9	10.5	13.3	14.3
			25 000 lb. Load				
N	.8c	2.8	12.4	21.7	24.1	27.1	29.9
E	.7	5.7	12.7	29.0	32.8	34.3	27.0
S	.9c	10.5	14.8	21.0	27.2	30.5	31.4
W	1.8	.8	15.8	26.3	24.5	25.2	26.2
Av.	.2	5.0	13.9	24.5	27.1	29.3	28.6
			30 000 lb. Load				
N	.3	4.5	14.3	32.2	44.8	42.5	46.6
E	2.7	4.2	11.7	52.0	57.5	53.3	44.7
S	3.9	11.5	14.7	37.8	42.2	47.3	47.4
W	3.2	2.2	17.2	40.2	36.9	35.6	34.0
Av.	2.5	5.6	14.5	40.5	45.3	44.7	43.2

c,- compression; all others are tension.

SLAB 1242. CONCRETE DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line D	E	F	G	5	6	7	8	9	10
				10 000 lb. Load						
N	1.2	.5	.1	1.2	.7	.1	.8	.7	1.4	.8
E	1.7	1.0	.3t	.7	1.0	1.2	1.1	.4	2.0	2.5
S	3.2	2.0	1.4	1.7	.9	3.2	2.7	2.2	2.9	2.1
W	1.7	1.0	1.4	1.7	.7	1.2	1.8	.7	1.9	3.0
Av.	1.9	1.1	.6	1.3	.8	1.4	1.6	1.0	2.0	2.3
				15 000 lb. Load						
N	3.6	1.4	.2	.4	1.3	1.4	2.5	2.3	2.4	2.8
E	3.0	2.2	.9	.4	1.9	1.7	2.0	.6	3.2	3.4
S	4.4	2.8	2.4	1.9	0	4.4	4.2	3.8	4.6	2.6
W	4.4	1.7	1.9	2.0	1.5	2.1	2.6	2.5	2.2	3.6
Av.	3.8	2.0	1.3	1.2	1.2	2.4	2.8	2.3	3.1	3.1
				20 000 lb. Load						
N	7.8	3.5	1.5	0	2.1	2.4	5.0	6.0	6.0	6.3
E	7.7	3.5	.2	.6	4.1	4.5	6.7	6.6	8.9	8.6
S	9.7	3.8	2.0	1.9	.9	5.3	7.1	8.2	10.5	6.8
W	8.5	2.8	3.0	2.1	2.7	4.5	7.0	6.7	7.5	7.6
Av.	8.4	3.4	1.7	1.1	2.4	4.2	6.4	6.9	8.2	7.3
				25 000 lb. Load						
N	16.3	7.4	2.5	1.2	1.5	3.8	8.6	13.0	12.9	11.2
E	19.5	6.1	1.0	.2	4.3	8.3	12.2	12.6	15.1	14.5
S	14.0	5.6	3.6	2.3	.8	9.3	12.1	14.6	16.6	13.3
W	18.0	4.6	3.1	.6	2.3	8.9	10.2	10.9	11.5	10.9
Av.	16.9	5.8	2.5	1.1	2.2	7.6	10.8	12.8	14.0	12.5
				30 000 lb. Load						
N	25.4	10.3	2.9	2.5	1.7	6.1	11.0	16.6	16.6	14.8
E	31.9	8.7	2.6	1.7	5.3	14.3	16.3	17.4	19.7	19.7
S	27.8	9.6	4.9	1.8	2.0	12.5	15.5	18.6	20.6	18.1
W	25.3	6.3	3.5	.6	3.0	12.3	13.1	13.6	14.1	15.3
Av.	27.6	8.7	3.5	1.6	3.0	11.3	14.0	16.5	17.7	17.0

t,- tension; all others are compression.

SLAB 1243. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line					
	*B'	C	D	E	F	G
			10 000 lb. Load			
N	39.2	2.5	1.3	.9	4.2	3.4
E	6.7	2.9	1.5	.5	1.4	2.0c
S	7.7	2.0	1.2	1.5	2.0	1.9
W	2.7	2.8	2.3	1.0	1.6	.2c
Av.	14.1	2.5	1.6	1.0	2.3	.8
			20 000 lb. Load			
N	114.1	16.2	12.0	8.9	14.8	5.7
E	7.5	9.3	11.2	10.0	8.1	3.5
S	12.5	15.8	12.5	5.6	1.5	1.4
W	8.5	13.6	11.6	8.0	5.4	1.1
Av.	35.6	13.7	11.8	8.1	7.4	2.9
			25 000 lb. Load			
N	191.5	24.9	16.3	12.0	16.4	8.9
E	81.7	15.3	16.0	13.7	12.5	8.9
S	16.0	25.7	19.7	12.2	5.7	3.9
W	79.1	28.7	19.9	14.0	12.5	8.8
Av.	92.1	23.7	18.0	13.0	11.8	7.6
			35 000 lb. Load			
N	217.6	35.0	25.8	23.5	34.4	18.1
E	111.0	14.2	17.7	12.0	12.4	14.0
S	67.3	27.8	29.0	18.8	11.3	7.1
W	105.8	13.6	21.0	17.0	24.4	11.0
Av.	125.4	22.6	23.4	17.8	20.6	12.5

c,- compression; all others are tension.

*,- 9 in. gage length. Differences include slip of rod at connection with plate.

SLAB 1243. TENSION DEFORMATIONS IN CONCRETE.

Corrected Differences for Strain Gage Readings.

	Gage line 4	5	6	7	8	9	10
			10 000 lb. Load				
N	2.4	.5c	.2c	2.5	.5	.8	1.3
E	.9c	.6	.2	1.4	.1	1.2	4.4
S	1.1c	0	.3c	.6	.2	.6c	.6
W	2.1c	1.1c	.9	.3	2.5	.6	2.5
Av.	.4c	.2c	.1	1.2	.8	.5	2.2
			20 000 lb. Load				
N	4.3	6.6	2.2	3.3	1.1	1.5	2.9
E	2.8	50.6	55.0	59.8	63.4	67.5	62.7
S	1.2c	3.9c	.4c	1.2c	.3c	1.8	3.2
W	1.7c	3.3c	13.3	12.0	14.0	9.0	7.2
Av.	1.o	12.5	17.3	18.5	19.5	19.4	19.0
			25 000 lb. Load				
N	21.4	6.9	2.5	2.4	1.8	.9	1.3
E	15.0	147.7	168.0	175.1	179.8	184.8	184.4
S	76.0	12.6c	2.5c	1.8c	.3c	2.6	1.1
W	3.6	2.8c	79.0	79.2	83.5	80.6	76.5
Av.	29.0	34.8	61.9	63.7	66.2	67.2	65.8
			35 000 lb. Load				
N	36.9	14.9	9.5	8.5	3.8	5.1	4.4
E	---------------- crack----------------------						
S		18.4c	.3c	3.0c	.8c	2.0	1.7
W	---------------- crack----------------------						
Av.	--						

c,- compression; all others are tension.

SLAB 1243. CONCRETE DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line									
	D	E	F	G	5	6	7	8	9	10
					10 000 lb. Load					
N	1.8	1.5	1.5	1.4	1.8	1.1	1.1	2.1	*.7t	2.5
E	2.1	.6	.8	.2	1.5	.9	3.7	2.1	1.4	.5
S	.5	.9	2.0	.2	.9	1.7	.3	1.1	.7	.7
W	2.7	.4	.1	.4	.9t	.8	2.5	1.7		.7
Av.	1.8	.8	1.1	.5	.8	1.1	1.9	1.7	1.0	1.1
					20 000 lb. Load					
N	7.1	3.7	2.7	1.9	4.5	2.1	2.1	1.9	*.4	3.1
E	9.9	3.0	2.0	.2	.7	7.0	12.2	10.0	10.9	7.7
S	8.1	2.1	2.7	.5t	2.9	4.5	3.4	6.2	3.5	1.7
W	12.3	2.4	.6	2.2t	2.6	3.5	5.8	5.6		1.6
Av.	9.3	2,8	2.0	.1t	2.7	4.3	5.9	5.9	7.2	3.7
					25 000 lb. Load					
N	7.4	3.1	3.0	1.7	8.8	3.7	3.6	4.2	*3.3	5.0
E	15.0	3.3	2.1	1.8	13.6	20.2	25.7	20.9	21.1	17.2
S	8.0	2.0	3.8	.5t	11.9	8.4	6.1	7.1	4.0	1.5
W	18.8	4.0	.5	2.7	9.2	14.4	16.6	17.9		12.0
Av.	12.3	3.1	2.3	1.4	10.9	11.7	13.0	12.5	12.5	8.9
					35 000 lb. Load					
N	8.0	2.9	2.4	1.0	9.7	6.0	5.5	6.7	*4.3	7.4
E	18.5	1.8	.7	.5t	34.5	43.3	47.3	41.4	44.6	41.9
S	8.5	3.2	4.2	.2t	21.0	14.1	10.6	10.7	6.6	5.6
W	36.4	5.1	.3t	2.3	23.2	33.2	39.2	37.8		35.3
Av.	17.8	3.2	1.7	.6	22.1	24.1	25.6	24.1	25.6	22.5

t,- tension; all others are compression.

*,- not included in average.

SLAB 1244. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line *B'	B	C	D	E	F	G
			10 000 lb. Load				
N	2.0	.7c	.5	.5	1.7	.1	.1
E	1.2	.6	1.6	1.7	.4	.3c	.3
S	.1	1.1	1.5	2.0	.5	.3	0
W	3.5	.3	2.6	2.7	.8	.2c	.3c
Av.	1.7	.3	1.5	1.7	.8	0	0
			15 000 lb. Load				
N	4.0	.6c	1.9	1.3	2.6	.1	1.6
E	3.0	1.6	2.5	4.2	3.6	.7	1.7
S	1.7	3.1	4.5	4.1	2.1	3.4	1.1
W	5.2	1.4	4.0	5.2	3.4	.2	1.6
Av.	3.5	1.4	3.2	3.7	2.9	1.1	1.5
			20 000 lb. Load				
N	39.0	4.4	10.6	9.2	5.0	.1	1.4
E	33.0	.6c	8.0	7.0	9.9	6.3	5.2
S	20.8	5.2	6.5	9.2	6.3	5.4	2.8
W	26.5	.9	8.4	12.2	4.0	3.0	2.5
Av.	29.8	2.5	8.4	9.4	6.3	3.7	3.0
			25 000 lb. Load				
N	129.0	.4	16.8	16.9	10.5	3.7	2.2
E	98.2	9.5c	13.0	11.5	15.7	13.0	8.3
S	64.3	1.2	14.8	16.3	12.1	11.5	7.9
W	84.5	16.0c	13.3	16.4	10.0	8.6	8.3
Av.	94.0	6.0c	14.5	15.3	12.1	9.2	6.7
			35 000 lb. Load				
N		10.6c	19.5	20.9	15.0	10.4	7.5
E	372.0	33.8c	25.6	17.8	17.7	17.1	8.3
S	162.3	21.2c	15.8	21.8	19.7	16.5	19.2
W		63.9c	18.8	25.7	14.3	16.4	15.5
Av.		32.4c	19.9	21.5	16.7	15.1	12.6
			45 000 lb. Load				
N		8.9c	23.0	26.5	15.9	15.2	14.2
E		38.9c	37.0	29.2	21.0	16.0	9.3
S	238.3	22.9c	16.6	23.4	26.3	16.8	27.7
W		89.8c	15.5	26.2	9.3	13.2	12.1
Av.		40.1c	23.0	26.3	18.1	15.3	15.8

c,- compression; all others are tension.

*,- 9 in gage length. Differences include slip of rod at connection with plate.

SLAB 1244. TENSION DEFORMATIONS IN CONCRETE.

Corrected Differences for Strain Gage Readings.

	Gage line 4	5	6	7	8	9	10
			10 000 lb. Load				
N	1.5c	0	.5c	1.7	1.4	2.4	5.9
E	.3	.9	1.4	1.6	1.7	3.5	4.0
S	2.4	1.6	1.5	.4	3.3	3.3	
W	1.0	1.7	2.4	1.4	1.7	1.0	1.1
Av.	.5	1.0	1.2	1.3	2.0	2.5	3.7
			15 000 lb. Load				
N	1.5	1.0c	1.2	3.1	2.9	7.0	8.9
E	4.8	2.0	12.2	22.2	23.8	28.3	30.5
S	8.9	10.4	13.3	13.4	21.8	21.9	
W	4.7	7.2	14.2	19.1	20.6	20.8	28.6
Av.	5.0	4.7	10.2	14.4	17.3	19.5	22.7
			20 000 lb. Load				
N	38.7	2.6c	1.8	4.7	3.4	8.8	11.2
E	70.3	2.3	96.3	125.3	130.3	134.8	138.0
S	15.5	127.6	30.5	34.2	148.3	153.1	
W	4.2	103.9	121.8	131.0	134.3	134.0	140.7
Av.	32.2	57.8	62.6	73.8	104.1	107.7	96.6
			25 000 lb. Load				
N	132.3	2.0c	.3	14.9	4.7	12.0	12.2
E	278.9	1.5	295.0	---------crack---------------			
S	304.5	---------------------------crack---------------					
W	---------------------------------crack---------------						
Av.	---						
			35 000 lb. Load				
N	294.3	4.1c	13.3	28.4	11.1	16.7	14.3
E,S,W,	------------------------crack---------------						
			45 000 lb. Load				
N		8.2c	22.4	55.3	58.5	61.7	59.4
E,S,W,	------------------------crack---------------						

c,- compression; all others are tension.

SLAB 1244. CONCRETE DEFORMATIONS.

Corrected Differences fpr Strain Gage Readings.

	Gage line									
	D	E	F	G	5	6	7	8	9	10
				10 000 lb. Load						
N	.5	.4	1.1	2.0t	.7	.3	.7	.2	1.1	.2
E	2.2	1.6	.5	.3	.6	.4	.4	.9	.9	.1t
S	3.0	.9	.4	1.4t	.1	1.6	.4	.5	0	.6
W	1.5	.6t	.1t	2.4t	.5	.5	.2	.5	1.4	.3
Av.	1.8	.6	.5	1.4t	.5	.7	.4	.5	.8	.2
				15 000 lb. Load						
N	3.0	3.7	2.5	1.0t	1.2	1.1	4.5	2.0	1.3	3.1
E	3.8	1.6	.6	.2	1.7	3.3	4.7	7.0	6.4	4.9
S	5.3	2.6	1.7	.2t	1.8	5.8	3.0	6.0	6.2	4.8
W	.2	1.0	.7	.3	1.9	2.9	4.4	5.4	5.2	4.5
Av.	3.1	2.2	1.4	.2t	1.6	3.3	4.1	5.1	4.8	4.3
				20 000 lb. Load						
N	5.5	2.4	.7t	.5t	1.4	1.8	5.4	2.7	3.9	3.7
E	5.0	2.8	1.9	.5t	11.5	12.4	13.3	18.5	18.7	16.2
S	6.0	3.5	2.5	0	12.4	15.6	15.7	19.3	17.5	13.2
W	3.9	1.7	.4	.5t	10.9	12.7	15.4	16.3	14.7	11.5
Av.	5.1	2.6	1.0	.4t	9.0	10.6	12.4	14.2	13.7	11.1
				25 000 lb. Load						
N	14.7	4.9	.5	.7t	4.3	5.6	7.1	3.2	5.8	10.0
E	6.9	2.8	2.6	.9t	27.5	25.7	29.6	32.4	36.5	31.2
S	7.4	4.6	3.0	1.6t	26.2	29.3	27.7	33.7	32.0	26.5
W	7.5	.9	.5	.3t	19.1	20.9	25.8	27.0	25.4	20.4
Av.	9.1	3.3	1.6	.9t	19.3	20.4	22.5	24.1	24.9	22.0
				35 000 lb. Load						
N	14.0	2.8	.6t	1.4t	10.7	10.6	10.8	7.7	8.9	9.5
E	11.5	3.8	2.0	1.4t	41.9	41.0	45.4	49.5	55.7	50.2
S	11.8	6.7	2.1	2.4t	37.4	46.3	47.2	55.7	58.0	55.2
W	11.4	1.9	.4t	3.6t	39.6	42.6	51.6	55.2	52.0	46.9
Av.	12.2	3.8	.8	2.2t	32.4	35.1	38.7	42.0	43.6	40.4
				45 000 lb. Load						
N	14.6	3.3	1.3t	2.2t	14.8	17.5	21.5	20.5	19.6	20.1
E	19.3	5.0	1.3	3.2t	54.9	55.1	57.6	65.4	74.0	68.1
S	19.6	7.2	.9	4.8t	49.0	60.5	64.6	75.4	81.9	81.5
W	15.6	2.7	.6t	5.5t	54.6	60.7	72.5	79.2	74.7	69.5
Av.	17.3	4.5	.1	3.9t	43.3	48.4	54.0	60.1	62.5	59.8

t,- tension; all others are compression.

SLAB 1245. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line					
	*A	B	C	D	E	F
			10 000 lb. Load			
N	1.0	1.2	3.0	2.7	2.2	1.4
E	.5	.6	2.1	2.5	1.9	1.2
S	.6	1.2	2.7	2.6	2.2	2.3
W	1.9	1.3	2.7	3.1	2.8	1.7
Av.	1.0	1.1	2.6	2.7	2.3	1.6
			20 000 lb. Load			
N	2.6	5.3	8.4	8.9	5.3	3.5
E	2.6	4.9	8.2	6.3	4.7	3.9
S	3.2	4.7	8.0	8.8	5.6	4.5
W	4.1	3.0	8.1	8.3	6.8	3.6
Av.	3.1	4.5	8.2	8.1	5.6	3.9
			30 000 lb. Load			
N	5.5	9.4	13.2	15.8	11.8	8.4
E	7.8	5.8	13.2	12.5	10.1	6.0
S	4.4	8.8	14.2	14.4	11.6	8.6
W	7.6	6.0	11.8	14.6	14.0	9.3
Av.	6.3	7.5	13.4	14.3	11.9	8.1
			40 000 lb. Load			
N	13.0	13.8	19.6	21.0	16.3	13.4
E	10.3	9.9	17.5	17.1	13.3	9.2
S	6.9	1o.8	17.6	18.1	13.9	11.6
W	12.8	10.5	15.5	20.4	18.2	14.7
Av.	10.7	11.2	17.5	19.1	15.4	12.2
			50 000 lb. Load			
N	35.7	18.1	24.4	25.7	19.9	17.3
E	44.9	15.7	23.0	21.5	17.9	13.6
S	20.7	14.7	19.9	24.9	16.0	13.5
W	33.1	17.9	20.1	26.8	20.9	17.7
Av.	33.6	16.6	21.8	24.7	18.7	15.5
			60 000 lb. Load			
N	51.2	22.1	29.9	41.6	19.1	22.6
E	58.3	16.3	25.7	32.9	15.8	16.3
S	31.6	17.6	24.6	44.3	11.2	20.0
W	51.2	19.5	23.7	54.7	20.0	20.6
Av.	48.1	18.9	26.0	43.4	16.5	19.9

*,- 6 in gage length. Differences include slip of rod at connection with plate.

All differences are tension.

SLAB 1245. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line 4	5	6	7	8	9
			10 000 lb. Load			
N	2.0	2.4	2.2	2.8	1.9	2.0
E	1.9	1.4	1.6	2.6	2.4	2.5
S	1.7	2.1	3.8	3.0	3.5	3.2
W	2.0	1.8	1.4	2.9	1.7	1.5
Av.	1.9	1.9	2.3	2.8	2.4	2.3
			20 000 lb. Load			
N	5.5	5.3	6.8	6.1	4.6	5.0
E	4.2	5.8	6.6	6.6	8.7	7.5
S	4.5	5.9	7.7	7.7	9.6	8.7
W	3.1	4.7	4.6	6.1	5.3	5.6
Av.	4.3	5.4	6.4	6.6	7.0	6.7
			30 000 lb. Load			
N	5.1	5.3	7.8	14.5	13.9	12.2
E	4.2	7.3	8.2	14.8	14.7	14.6
S	5.3	7.5	8.6	17.4	16.9	15.4
W	3.8	5.3	9.7	13.6	14.1	13.6
Av.	4.6	6.3	8.6	15.1	14.9	13.9
			40 000 lb. Load			
N	7.8	6.1	10.5	23.6	22.3	21.8
E	5.1	9.8	10.6	22.8	25.7	22.5
S	6.2	9.1	9.7	26.1	24.5	21.4
W	5.0	6.0	13.1	19.8	23.1	23.2
Av.	6.0	7.7	11.0	23.1	23.9	22.2
			50 000 lb. Load			
N	20.1	17.3	19.4	39.1	38.7	37.1
E	16.6	20.6	19.3	37.2	38.7	32.9
S	15.9	18.5	17.9	45.9	39.8	31.6
W	17.6	14.8	20.1	31.0	47.1	37.7
Av.	17.5	17.8	19.2	38.3	41.1	34.8
			60 000 lb. Load			
N	25.4	22.8	24.0	52.9	64.6	57.3
E	21.7	25.1	23.1	42.2	73.3	60.8
S	21.8	22.9	19.8	60.7	79.2	67.6
W	21.7	18.8	21.1	34.8	77.2	67.8
Av.	22.6	22.4	22.0	47.6	73.6	63.4

All differences are tension.

SLAB 1245. CONCRETE DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line									
	D	E	F	G	5	6	7	8	9	10
				10 000 lb. Load						
N	4.1	2.8	1.5	.4		1.3	1.6	2.0	2.5	2.1
E	3.3	2.0	2.0	1.3	.5	2.6	2.3	2.9	3.4	2.8
S	3.6	2.5	4.7	2.3	1.8	2.2	2.0	3.7	3.3	3.7
W	3.5	3.0	2.4	1.4		2.4	1.8	1.7	2.2	1.8
Av.	3.6	2.6	2.6	1.3	1.2	2.1	1.9	2.6	2.8	2.6
				20 000 lb. Load						
N	9.0	4.4	1.6	.6		2.4	2.6	2.4	3.8	3.1
E	7.5	3.9	3.0	.6	1.1	4.4	5.7	5.9	6.3	6.1
W	7.4	4.8	3.0	1.7		2.8	2.2	3.6	4.5	4.0
S	7.1	4.4	4.7	2.3	2.7	4.1	5.7	6.9	7.7	5.7
Av.	7.7	4.4	3.1	1.3	1.9	3.4	4.0	4.7	5.6	4.7
				30 000 lb. Load						
N	14.9	6.2	3.2	2.1		6.7	7.9	7.9	9.8	8.8
E	13.3	5.7	3.7	.3	1.3	6.4	9.6	9.6	10.0	9.8
S	11.7	5.7	7.7	1.4	4.0	7.1	9.2	11.1	11.6	10.3
W	14.2	6.6	3.8	2.5		4.1	6.1	8.0	9.7	9.0
Av.	13.5	6.0	4.6	1.6	2.7	6.1	8.2	9.1	10.3	9.5
				40 000 lb. Load						
N	21.6	8.3	3.8	2.9		10.9	12.5	13.4	14.6	14.4
E	17.5	8.4	4.3	1.9	4.3	10.8	13.0	12.7	13.4	13.6
S	16.2	7.0	6.9	2.7	6.4	10.1	13.6	14.8	14.7	13.5
W	20.7	9.0	5.7	2.8		7.9	11.4	13.0	15.0	13.8
Av.	19.0	8.2	5.2	2.6	5.4	9.9	12.6	13.5	14.4	13.8
				50 000 lb. Load						
N	27.3	8.9	3.6	2.7		17.7	18.4	19.1	19.0	19.8
E	20.2	9.4	4.1	2.0	12.2	18.2	19.6	17.7	17.2	16.9
S	16.7	10.0	8.9	2.7	12.9	16.5	18.8	20.7	19.5	18.2
W	26.5	10.0	5.1	2.0		14.4	17.4	19.2	19.4	19.2
Av.	22.7	9.6	5.4	2.3	12.6	16.7	18.5	19.2	18.8	18.5
				60 000 lb. Load						
N	32.3	9.3	5.9	1.6		23.9	23.6	24.3	25.1	26.2
E	31.9	10.8	4.5	1.5	14.4	24.7	26.2	24.5	24.1	22.1
S	23.0	11.5	7.8	1.7	19.2	25.5	25.3	26.7	26.7	25.6
W	27.2	10.5	6.1	1.9		22.3	23.6	24.5	26.5	25.0
Av.	28.6	10.5	6.1	1.7	16.8	24.1	24.7	25.0	25.6	24.7

All differences are compression.

SLAB 1246. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line *A	B	C	D	E	F	G
			10 000 lb. Load				
N	1.2	1.0	1.3	1.3	1.7	1.1	2.1
E	.6	1.9	2.0	2.7	1.8	.8	.5
S	1.3	2.6	3.0	4.1	2.0	1.7	
W	1.5	.5	1.6	1.6	.1	.3	
Av.	1.1	1.5	2.0	2.4	1.4	1.0	1.3
			20 000 lb. Load				
N	1.6	1.4	4.8	3.3	3.2	1.6	1.8
E	.9	2.4	6.7	5.6	2.2	1.1	1.1
S	2.2	3.0	6.6	7.5	3.3	2.1	
W	2.6	4.4	7.3	6.5	4.2	4.2	
Av.	1.8	2.8	6.3	5.7	3.2	2.2	1.4
			30 000 lb. Load				
N	2.8	6.3	11.9	10.3	7.5	3.5	4.1
E	2.4	5.9	14.8	13.8	7.6	5.2	2.2
S	3.7	6.5	11.9	14.8	8.2	6.3	
W	3.5	5.8	13.4	12.4	8.3	7.2	
Av.	3.1	6.1	13.0	12.8	7.9	5.5	3.1
			40 000 lb. Load				
N	17.6	10.1	16.7	16.4	12.5	8.8	3.1
E	9.5	7.5	21.9	23.6	15.7	11.2	3.1
S	8.2	12.0	17.5	22.9	15.0	13.4	
W	9.5	10.7	19.9	20.3	13.4	13.8	
Av.	11.2	10.1	19.0	20.8	14.1	11.8	3.1
			50 000 lb. Load				
N	40.3	12.4	18.4	17.9	16.3	10.6	3.7
E	27.0	12.3	23.9	25.4	18.8	14.3	4.9
S	23.3	14.0	20.8	26.0	16.8	16.6	
W	24.2	11.5	20.5	23.2	13.6	15.9	
Av.	28.7	12.5	20.9	23.1	16.4	14.3	4.3
			60 000 lb. Load				
N	58.1	15.9	24.2	24.2	17.9	17.0	11.6
E	40.4	17.7	29.1	32.4	22.8	19.0	10.0
S	33.8	17.1	27.0	34.3	23.8	24.1	
W	35.2	12.2	23.6	27.0	12.2	16.5	
Av.	41.9	15.7	26.0	29.5	19.2	19.1	10.8

*,- 6 in. gage length. Differences include slip of rod at connection with plate.

All differences are tension.

SLAB 1246. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line 4	5	6	7	8	9	10
			10 000 lb. Load				
N	1.0	1.5	1.8	1.3	2.4	2.3	3.8
E	2.0	2.5	2.8	2.7	3.5	2.9	2.1
S	2.8	1.9	4.1	2.7	2.5	1.9	1.8
W	.1	1.5	1.9	2.5	4.0	.7	.5
Av.	1.5	1.8	2.6	2.3	3.1	1.9	2.0
			20 000 lb. Load				
N	2.1	1.8	4.6	3.7	4.2	4.9	4.3
E	2.5	2.8	5.2	4.3	4.5	3.1	4.9
S	2.4	3.7	7.4	4.4	5.6	5.1	5.3
W	1.7	4.9	8.3	7.6	11.4	8.5	7.5
Av.	2.2	3.3	6.4	5.0	6.4	5.4	5.5
			30 000 lb. Load				
N	6.3	5.7	10.2	7.1	12.7	13.4	10.9
E	5.5	4.8	9.2	9.9	13.1	12.2	15.3
S	2.8	7.5	10.1	12.6	13.6	13.0	14.6
W	5.3	8.0	12.1	12.4	15.8	14.2	13.7
Av.	5.0	6.5	10.4	10.5	13.8	13.2	13.6
			40 000 lb. Load				
N	10.3	10.0	16.7	16.1	21.4	20.3	17.3
E	8.8	7.8	14.3	16.1	20.4	19.4	21.8
S	6.8	12.2	15.8	20.8	21.5	22.3	22.1
W	5.9	8.7	15.3	16.9	22.2	22.2	21.3
Av.	7.9	9.7	15.5	17.5	21.4	21.0	20.6
			50 000 lb. Load				
N	21.2	20.6	25.6	21.3	32.2	28.7	23.1
E	13.1	18.4	25.6	26.7	28.8	27.2	26.3
S	23.5	21.8	25.1	30.4	31.9	30.2	27.8
W	19.3	18.2	26.8	29.8	35.3	29.7	25.8
Av.	19.3	19.7	25.8	27.0	32.0	28.9	25.7
			60 000 lb. Load				
N	31.2	29.6	35.7	30.9	45.1	42.6	35.7
E	30.3	24.3	33.1	36.1	39.8	39.1	32.7
S	30.6	29.3	31.0	39.4	44.3	40.8	39.9
W	27.1	25.9	33.3	38.4	46.9	40.8	33.4
Av.	29.8	27.3	33.3	36.2	44.0	40.8	35.4

All differences are tension.

SLAB 1246. CONCRETE DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line D	E	F	G	5	6	7	8	9	10
				10 000 lb. Load						
N	.9	.2	.8	0	.5	.6	.4	.2	1.2	.4
E	1.9	.6	.9	1.1t	.3	1.6	.9	.8	.4	.4
S	1.3	.5	.5	.4	.3	.8	.9	1.2	1.6	.3
W	1.3	.3	.4	.1	.1	.1	.2	.5	.9	2.2
Av.	1.3	.4	.6	.1t	.3	.8	.6	.7	1.0	.8
				20 000 lb. Load						
N	4.2	2.7	2.1	.9	1.3	2.0	2.7	3.8	3.4	2.6
E	5.5	3.3	2.1	.5t	.9	.8	2.0	1.9	2.4	3.4
S	4.7	2.2	1.8	.9	1.5	3.1	4.0	3.4	3.5	1.8
W	2.8	1.2	.7	.7	1.8	3.6	3.6	3.5	3.0	4.9
Av.	4.3	2.3	1.7	.5	1.4	2.4	3.1	3.1	3.1	3.2
				30 000 lb. Load						
N	10.0	5.3	2.5	.1	2.0	3.4	5.7	5.7	6.8	4.4
E	10.4	5.1	3.0	.1t	1.6	3.6	4.7	5.6	7.7	7.2
S	10.3	4.4	3.1	.9	1.2	5.4	6.6	7.1	6.1	4.9
W	11.1	3.4	.3	1.0	3.8	5.9	6.6	7.8	7.9	7.5
Av.	10.4	4.5	2.2	.5	2.1	4.6	5.9	6.5	7.1	6.0
				40 000 lb. Load						
N	16.4	7.7	3.5	.5	4.8	5.8	7.8	8.7	9.9	7.0
E	16.2	7.3	4.7	.7	2.3	5.2	8.3	8.7	10.2	10.1
S	17.9	6.9	3.5	1.4	3.2	9.1	10.2	10.7	10.2	7.0
W	17.4	6.0	1.2	.5	5.1	9.0	9.4	11.3	10.9	12.6
Av.	17.0	7.0	3.2	..8	3.8	7.3	8.9	9.8	10.3	9.2
				50 000 lb. Load						
N	21.5	8.0	3.1	0	11.1	11.0	14.1	14.3	13.2	11.3
E	20.2	9.2	6.0	.2	8.5	12.4	14.6	14.1	14.3	14.4
S	21.7	10.2	3.5	.7	10.7	16.2	17.9	17.8	15.2	11.9
W	23.0	7.5	1.3	.9	12.2	16.3	16.3	17.2	14.8	16.5
Av.	21.6	8.7	3.5	.4	10.6	14.0	15.7	15.8	14.4	13.5
				60 000 lb. Load						
N	26.9	9.0	3.3	.4	16.6	14.8	20.6	18.4	17.5	16.7
E	26.8	11.9	6.0	.6	12.6	16.3	18.4	16.8	16.5	15.9
S	27.2	12.4	4.1	1.2	15.5	21.2	22.4	22.1	19.8	16.1
W	29.0	7.2	1.3	.4	15.7	19.8	19.9	20.3	17.7	17.7
Av.	27.5	10.1	3.7	.6	15.1	18.0	20.3	19.4	17.9	16.6

t,- tension; all others are compression.

SLAB 1247. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line A	B	C	D	E	F	G	1	2	3	4
					10 000 lb. Load						
N	2.0	3.0	3.8	3.4	3.1	4.0	.5	1.7	1.9	1.0	2.8
E	2.2	2.3	4.3	2.4	1.6	3.8	1.0	1.9	1.0	2.0	2.9
S	2.0	1.7	2.7	2.5	2.3	1.2	1.4	.7	2.4	1.3	1.7
W	1.4	1.3	1.7	3.2	2.6	2.1	1.5	1.7	2.0	1.7	1.2
Av.	1.9	2.1	3.1	2.9	2.4	2.8	1.1	1.5	1.8	1.5	2.1
					20 000 lb. Load						
N	2.9	4.8	7.8	9.1	4.0	4.2	1.7	1.8	1.8	2.0	3.3
E	2.7	3.2	7.7	7.5	2.0	4.2	1.9	1.9	1.5	2.9	4.6
S	2.5	2.9	7.9	8.3	5.2	3.1	2.1	1.0	3.1	1.8	2.6
W	2.3	2.4	6.3	7.2	4.0	3.7	1.6	1.7	2.1	1.5	1.9
Av.	2.6	3.3	7.4	8.0	3.8	3.8	1.8	1.6	2.1	2.0	3.1
					30 000 lb. Load						
N	2.7	5.5	14.7	15.9	6.8	5.8	1.9	1.5	1.7	1.9	5.1
E	3.1	6.1	13.1	12.1	7.6	6.3	3.3	2.4	2.7	3.7	8.3
S	3.0	6.9	16.4	15.6	11.6	5.4	3.4	1.4	3.3	2.4	5.9
W	2.6	5.7	12.3	13.2	10.9	7.5	3.4	3.5	3.0	3.1	4.4
Av.	2.8	6.0	14.1	14.2	9.2	6.2	3.0	2.2	2.7	2.8	5.9
					40 000 lb. Load						
N	4.0	11.6	25.0	27.3	14.5	8.6	3.8	1.9	3.1	3.0	9.6
E	4.8	10.2	19.6	19.9	14.0	12.8	5.2	3.3	5.9	10.0	15.9
S	5.2	13.7	26.5	22.7	16.8	6.1	3.1	1.5	3.1	3.6	13.2
W	3.8	9.9	18.1	19.2	15.5	12.5	7.0	5.4	3.8	7.2	8.4
Av.	4.4	11.3	22.3	22.3	15.2	10.0	4.8	3.0	4.0	6.0	11.8
					50 000 lb. Load						
N	7.0	16.7	29.0	29.1	20.2	17.4	9.5	4.7	6.8	8.5	14.5
E	8.9	15.8	24.9	23.9	17.6	16.0	10.2	4.2	12.0	12.0	24.1
S	11.2	18.9	34.2	30.2	22.8	9.9	2.7	6.3	5.1	6.9	20.2
W	7.0	14.4	23.3	24.1	19.4	16.7	13.5	10.9	7.0	13.6	16.7
Av.	8.5	16.4	27.8	26.8	20.0	15.0	9.0	6.5	7.7	10.2	18.9
					60 000 lb. Load						
N	10.0	19.0	31.4	33.4	24.0	23.6	14.5	10.4	10.5	13.8	20.3
E	14.6	20.3	32.6	28.1	21.0	18.5	13.5	6.5	17.7	15.8	31.3
S	15.0	22.7	40.7	35.6	28.9	15.2	3.6	12.8	7.3	10.9	27.3
W	9.8	17.4	27.3	29.5	24.2	22.9	18.2	16.3	10.6	19.9	21.0
Av.	12.3	19.8	33.0	31.6	24.5	20.0	12.4	11.5	11.5	15.1	25.0
					70 000 lb. Load						
N	15.0	25.0	38.8	43.9	30.9	31.2	26.5	17.1	15.4	19.8	30.1
E	19.4	25.0	39.1	35.8	26.6	27.3	21.7	10.3	20.7	21.0	36.9
S	19.0	25.1	63.9	49.5	32.6	21.4	8.9	14.5	10.3	18.7	37.0
W	14.8	23.1	37.1	37.3	31.4	29.8	25.8	24.2	15.1	25.4	29.5
Av.	17.0	24.5	44.7	41.6	30.4	27.4	20.7	16.5	15.4	21.2	33.4
					78 000 lb. Load						
N	35.0	37.6	----	----	43.5	46.6	29.5	41.4	38.1	38.8	136.1
E	33.6	42.1	84.3	41.1	----	32.8	31.5	26.5	40.7	50.5	124.1
S	48.0	37.9	----	----	35.6	26.0	10.4	38.5	37.1	40.1	112.9
W	27.0	30.7	86.3	35.3	125.1	----	----	43.5	51.8	63.1	72.5
Av.	35.9	37.1	----	----	----	----	----	37.5	41.9	48.1	111.4

All differences are tension.

SLAB 1247. STEEL DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line 5	6	7	8	9	10	11	12	13	14
				10 000 lb. Load						
N	2.2	3.0	2.6	1.8	3.8	3.6				
E	2.7	1.4	1.3	2.7	2.7	1.7	2.9	3.0	2.9	2.8
S	1.0	1.1	1.1	3.1	1.7					
W	1.7	2.2	1.8	1.6	1.2	2.1	2.7	1.5	2.0	1.7
Av.	1.9	1.9	1.7	2.3	2.3	2.5	2.8	2.2	2.5	2.2
				20 000 lb. Load						
N	4.3	4.9	6.1	5.9	7.1	7.9				
E	6.0	5.6	6.0	7.9	8.4	8.1	7.1	8.2	7.1	6.2
S	3.6	4.8	4.5	5.6	4.8					
W	3.9	4.2	5.8	6.3	5.6	5.2	7.9	6.0	7.2	6.0
Av.	4.4	4.9	5.6	6.4	6.5	7.1	7.5	7.1	7.1	6.1
				30 000 lb. Load						
N	9.1	13.3	11.5	13.5	13.3	13.0				
E	12.1	12.3	13.3	15.5	16.7	17.7	14.3	16.0	14.8	12.1
S	11.0	10.3	11.1	12.5	8.8					
W	8.8	12.5	12.9	14.0	11.8	12.1	15.7	12.2	13.8	14.2
Av.	10.2	12.1	12.2	13.9	12.6	14.3	15.0	14.1	14.3	13.1
				40 000 lb. Load						
N	15.8	22.3	18.6	20.3	21.3	18.1				
E	18.7	19.0	19.3	22.6	23.2	24.5	21.8	24.4	22.4	20.9
S	18.0	15.0	15.2	18.2	12.5					
W	16.6	19.5	21.4	19.6	17.2	15.9	22.7	16.9	20.1	23.2
Av.	17.3	19.2	18.6	20.2	18.5	19.5	22.2	20.6	21.2	22.0
				50 000 lb. Load						
N	23.1	29.8	26.1	26.8	25.3	22.2				
E	25.1	27.3	25.6	28.7	27.7	28.5	29.7	32.7	28.6	30.6
S	21.7	23.6	24.4	22.7	18.1					
W	23.7	26.8	26.2	24.6	21.6	19.8	31.2	22.2	28.0	28.0
Av.	23.4	26.9	25.6	25.7	23.2	23.5	30.4	27.4	28.3	29.3
				60 000 lb. Load						
N	31.8	38.7	33.4	33.8	30.3	27.7				
E	30.0	33.5	32.2	35.5	31.1	32.5	34.4	39.0	35.2	38.4
S	27.1	30.4	30.7	28.4	22.4					
W	30.8	33.1	33.0	30.9	26.6	23.6	39.4	28.5	37.2	37.0
Av.	29.9	33.7	32.3	32.1	27.6	27.9	36.9	33.7	36.2	37.7
				70 000 lb. Load						
N	43.0	49.2	46.5	44.0	40.6	35.4				
E	39.3	46.8	41.3	51.7	42.1	37.0	37.4	75.4	42.5	69.8
S	38.3	41.0	48.3	37.2	32.2					
W	45.8	47.7	54.2	43.2	36.8	29.6	73.7	39.9	82.5	61.8
Av.	41.6	46.2	47.6	44.0	37.9	34.0	55.5	57.6	62.5	65.8
				78 000 lb. Load						
N	----	----	----	----	156.5	191.6				
E	----	----	----	----	-----	-----	62.0	----	----	----
S	128.0	205.6	123.8	238.2	226.8	-----				
W	-----	-----	-----	-----	-----	-----	----	----	----	----
Av.	-----	-----	-----	-----	-----	-----	----	----	----	----

All differences are tension.

SLAB 1247. CONCRETE DEFORMATIONS.

Corrected Differences for Strain Gage Readings.

	Gage line									
	D	E	F	G	5	6	7	8	9	10
				10 000 lb. Load						
N	.9	.2	.2t	.5	1.1t	2.1t	.2	.5t	.8	.5
E	3.6	1.0	.9t	.1t	1.4t	.7t	.5	.4	.2	1.9
S	1.8	1.4	.2	.7	.4t	.3	.2	.4	.7	.7
W	1.2	.5	1.2	1.5t	.1	.9	.4	.5	.6	.7
Av.	1.9	.8	.1	.1t	.7t	.4t	.3	.2	.6	.9
				20 000 lb. Load						
N	5.1	2.5	1.7	.7	.7	.4	1.9	2.6	3.9	3.1
E	7.2	3.8	.6	.8t	0	2.2	3.0	2.8	3.2	4.0
S	6.0	3.0	.4	.3t	1.1	1.1	2.4	1.9	1.9	.9
W	4.6	1.3	.6	1.0t	.1t	2.2	1.4	2.7	2.1	2.6
Av.	5.7	2.6	.8	.3t	.1	1.5	1.8	2.6	2.8	2.6
				30 000 lb. Load						
N	9.3	3.3	2.2	.1	2.2	2.5	4.7	5.5	6.6	4.6
E	14.0	5.6	.7	1.4	3.1	5.5	6.3	6.9	7.6	7.0
S	11.5	6.3	1.9	.2	1.7	2.7	3.6	5.0	3.8	2.0
W	10.4	5.3	3.0	0	2.7	5.9	5.6	5.4	5.7	4.1
Av.	11.3	5.1	1.9	.4	2.4	4.1	5.0	5.7	5.9	4.4
				40 000 lb. Load						
N	14.6	6.6	2.6	.4	4.0	6.2	7.7	9.8	10.6	8.5
E	22.6	9.0	3.4	2.7	5.8	9.1	11.5	10.8	12.6	12.2
S	17.1	8.8	4.2	1.6	2.2	4.8	5.5	7.8	6.6	3.6
W	16.2	9.2	4.7	.4	4.3	8.4	8.4	9.2	8.1	5.4
Av.	17.6	8.4	3.7	1.3	4.1	7.1	8.3	9.4	9.5	7.4
				50 000 lb. Load						
N	17.6	7.5	3.6	.3	5.7	8.6	9.8	11.5	12.8	11.1
E	28.9	11.7	4.7	1.8	9.4	12.8	13.8	15.0	15.4	15.0
S	21.0	10.1	5.0	1.5	4.6	7.2	9.1	10.0	9.7	6.6
W	22.5	11.2	6.5	.4	5.7	11.1	10.4	11.9	11.0	9.2
Av.	22.5	10.1	5.0	1.0	6.3	9.9	10.8	12.1	12.2	10.5
				60 000 lb. Load						
N	21.8	8.3	4.2	.4t	9.4	11.8	12.7	13.2	14.0	11.1
E	36.7	14.5	6.2	1.5	12.2	15.5	15.2	17.9	17.3	18.4
S	25.2	10.6	4.9	1.3	6.1	11.0	11.4	12.9	10.8	7.3
W	28.7	12.8	7.7	.7	7.4	13.5	14.1	14.2	12.4	10.3
Av.	28.1	11.5	5.7	.8	8.8	12.9	13.4	14.5	13.6	11.8
				70 000 lb. Load						
N	26.3	9.4	4.7	1.6t	13.0	17.5	17.1	17.3	18.1	15.6
E	44.8	16.1	6.6	.4	18.2	20.8	20.2	22.3	22.3	21.4
S	30.4	12.6	4.6	.4	9.3	15.7	15.6	16.7	14.3	10.3
W	36.4	13.5	8.3	.9	10.2	19.7	18.2	16.8	18.7	13.6
Av.	34.5	12.9	6.0	0	12.7	18.4	17.8	18.3	18.3	15.2
				78 000 lb. Load						
N	25.9	6.2	1.8	7.3t	47.1	50.4	49.2	50.4	54.5	55.4
E	55.5	11.8	2.9	4.8t	72.9	70.7	76.6	84.1	86.7	79.9
S	33.5	10.9	3.1	3.5t	28.2	32.5	39.6	52.4	47.5	53.3
W	50.7	11.0	3.0	4.9t	48.3	69.1	71.0	68.5	78.1	69.5
Av.	41.4	10.0	2.7	5.1t	49.1	55.7	59.1	63.8	66.7	64.5

t,- tension; all others are compression.